



Building the knowledge base for environmental action and sustainability

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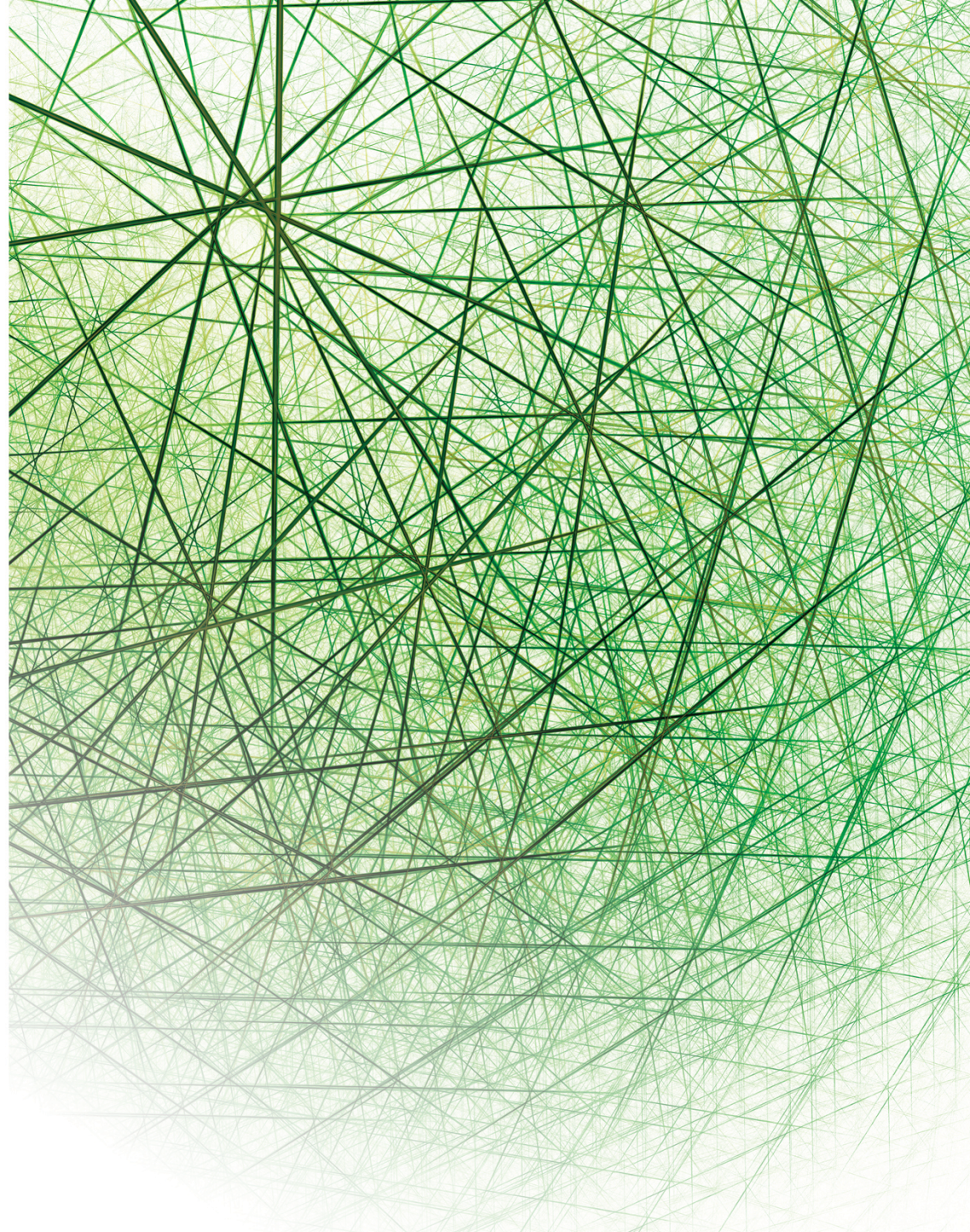
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EnviroInfo & ICT4S 2015



Adjunct Proceedings

7-9 September 2015, Copenhagen, Denmark

**Building the knowledge base for
environmental action and sustainability**



Title

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Adjunct Proceedings of the 29th International Conference on Informatics for Environmental Protection
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EnviroInfo & ICT4S

2015

29th International Conference on Informatics for Environmental Protection
3rd International Conference on ICT for Sustainability
7th – 9th September Copenhagen

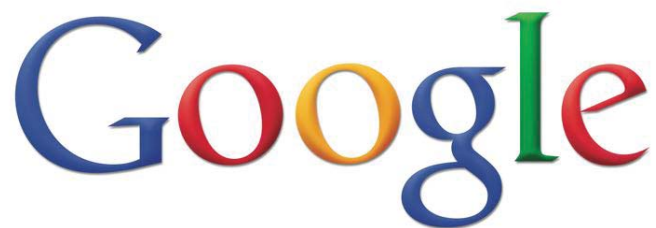
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Preface

“Knowledge is power” (Sir Francis Bacon (1561 – 1626), Religious Meditations, Of Heresis, 1597)

“Science is organised knowledge. Wisdom is organised life” (Immanuel Kant (1724 – 1804))

The 29th International Conference on Informatics for Environmental Protection and the third International Conference on ICT for Sustainability, EnviroInfo & ICT4S 2015, took place as a joint conference in Copenhagen in September 7-9 2015 and was hosted by the University of Copenhagen and the European Environment Agency.

EnviroInfo is a series of conferences under the umbrella of the German Computer Society (GI) and its Special Interest group Environmental Informatics, Informatics for Environmental Protection, Sustainability and Risk Management, which has a longstanding tradition of discussing fundamental aspects in the field of Environmental Informatics.

ICT4S is a series of research conferences bringing together leading researchers, developers and government and industry representatives, dedicated to exploring and proposing how Information and Communication Technologies (ICT) can be used as a tool to reach sustainability goals.

EnviroInfo is about discussing concepts, methods and tools to process, analyse, and interpret environmental information and support the discourse of environmental issues. Over the years, EnviroInfo has gathered communities from European countries and aims to foster scientific progress by bringing together research and practice.

ICT for sustainability is about utilising the transformational power of ICT for making our world more sustainable: saving energy and material resources by creating more value from less physical input, increasing quality of life for ever more people, without compromising future generations' ability to meet their needs.

The theme of EnviroInfo & ICT4S 2015 was “Building the knowledge base for environmental action and sustainability”. The joint conference was designed to facilitate ‘within-the-domain’, as well as to create a space for developing synergies between the two communities.

Altogether 125 research and applied papers (including extended abstracts) from 42 countries were submitted, of which 81 papers from 30 countries were accepted for oral presentation. The papers were single reviewed by at least two reviewers.

In the Conference Proceedings, you will find 41 full research papers published by Atlantis Press. Furthermore, 26 applied papers and 14 extended abstracts of applied papers were published in the Adjunct Proceedings, together with abstracts of 26 poster submissions and 11 workshop descriptions.

The conference aims at renewing and vitalizing the concept of scientific conferences with the help of a partly new design, titled “ConverStations”, sessions which allow more time than usual for interaction of the highly competent participants. The facilitator Peter Woodward was responsible for the design and implementation of this. All research and applied papers in the two proceedings have therefore been arranged in the three ConverStation sessions. Whilst two sessions, titled Parallel Sessions, feature the extended abstracts of applied papers presented in plenary format.

In total, 12 papers were nominated for the Best paper, where 6 were nominated from each of the two communities. These were presented in ConverStation format, spread out across the three ConverStation sessions. The awards for Best papers and Student prizes were given on the last day of the conference.

In connection with the conference, a number of workshops were held before, during, and after the main conference. The workshop review process and program was made possible by the conference organisers and the success of the workshops was ensured by the workshop organisers.

The conference had not been possible without the contributions from 43 members of the program committee from EnviroInfo representing 13 countries, and the 52 members of the program committee from ICT4S representing 14 countries, ensuring a conference of high scientific standard.

An important part of any conference is the keynote speakers. This time was no exception. Contributions from (in order of appearance)

Katherine Richardson, Professor at University of Copenhagen

Mattias Höjer, Professor at KTH Royal Institute of Technology

Bonnie Nardi, Professor at School of Information and Computer Sciences, University of California, Irvine

Hans Bruyninckx, Executive Director of the European Environment Agency

Katja Rosenbohm, European Environment Agency

Hans Wendschlag, EMEA Program Manager Social & Environmental Responsibility, Hewlett-Packard

Joseph Kava, Vice President - Data Centers, Google, California

Special thanks to Tania Nielsen who has acted as key person for all organisational matters, including contact point for speakers and participants and for the publication of the Conference Proceedings and Adjunct Proceedings. Thanks to Daniel Vare who has supported the submissions process for ICT4S. Thanks to Sanja Novakovikj, who has acted as the primary contact point for publication of the conference program and book of abstracts.

Last but not least, we would like to thank the conference sponsors for their financial support and – no conference without them - all paper and poster authors, workshop organisers, helping hands, and participants for their work, enthusiasm and participation!

Copenhagen, September 2015

*Vivian Kvist Johannsen, Stefan Jensen, Volker Wohlgemuth, Chris Preist and Elina Eriksson
(Chair Persons and Proceedings Editors of EnviroInfo & ICT4S 2015)*

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Conference homepage

<http://www.enviroinfo2015.org>

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The Environmental Footprints Explorer - a database for global sustainable accounting

Konstantin Stadler^{*†}, Radek Lonka^{*}, Daniel Moran^{*}, Georgios Pallas^{*}, Richard Wood^{*}

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Abstract—Environmentally Extended Multi Regional Input Output tables and analysis (EE MRIOs) have emerged as one of the main tools to analyze resource use and environmental impacts across international supply chains. They provide insights into the life cycle impacts of the production and consumption of commodities world wide, taking into account the global supply chain of purchased commodities. Currently half a dozen EE MRIO databases are available which differ in their environmental and economic focus as well as in the level of detail. As these databases become increasingly large, it has become increasingly difficult for the non-input-output expert to access the most important attributes and results of basic calculations. Here we present an integrated web-platform, the Environmental Footprints Explorer (<http://www.environmentalfootprints.com>), designed to access indicator results calculated based on these databases. The main functionality of the web-platform include (1) exploring environmental accounts based on a single database (2) comparison between databases using a common classification system and (3) exporting analysis results visualization. The presented web-platform removes the obstacle for policy-makers and the public alike to access EE MRIO results.

I. INTRODUCTION

Evidence guided policy making aiming for lessening the negative environmental and social impacts of our society require a comprehensive accounting principle. Such a principle must not only take into account direct domestic emissions and resource usage but also make the connection across global production networks - ultimately we are often interested in what forms of consumption have driven the impacts caused in production processes.

Global Environmentally Extended Multi Regional Input-Output (EE MRIO) tables provide such a system by taking into account the interrelations between production and consumption. EE MRIO tables link supply chains from the source of an impact, across countries, across processing stages, and to the final consumer. As such, estimates can be made about the amount of greenhouse gas emissions occurring in China to produce steel used in European televisions, or the amount of land used in Brazil required to feed British consumers. An important aspect of EE MRIO tables is that they are macro level economy-wide systems that provide a holistic picture of global production and consumption.

During the last years, several EE MRIO databases have been published [1]. These databases differ in their environmental and regional focus and also due to the applied accounting principles and implementation details [2]–[4].

Analysing EE MRIO databases require a certain degree of training and the increasing size of the underlying matrices

also set high requirements on used hardware. Thus, although most of the databases are free to use the detailed results of the analysis of these databases are often hidden in the supplements of scientific articles and reports.

Here we present the Environmental Footprints Explorer (Figure 1), <http://www.environmentalfootprints.org>, a web platform which provide access to the calculated results of various EE MRIO databases. The included EE MRIO databases have been aggregated into a common classification framework in order to make them comparable. Therewith, the presented platform allows to compare the environmental impacts of production and consumption of goods and services.



Fig. 1. The Environmental Footprints Explorer

The rest of the article unfolds as follows. In the next section we give some background information on environmental accounting followed by an overview about recently published EE MRIO databases which are included in the Environmental Footprint Explorer. The development section describes the architecture of the web platform, the routines used for calculating the results and the Common Classification System [5] applied to the MRIOs in order to make them comparable. We then present the platform and highlight some use cases. We conclude with a description of the future development.

A. Environmental Accounting

Principally, pressures arising from economic activity can either be tallied at the actual place of production or at the point of the consumption. Traditionally, the accounting at the actual place of production has been used for policy decisions. For example, the Kyoto Protocol was based on the production

principle, which is now discussed to be one of the reasons for its limited success [6].

Consumption based accounting (CBA), on the other hand, has been gaining momentum for policy making [7] as increasing globalisation of production networks occur. In CBA, all resource use and environmental pressures (for example emissions) occurring along the supply chain of products are added up and allocated to the final consumer of the product. This allows to assess the environmental pressure caused by a domestic demand abroad [8], [9].

Indicators based on consumption based accounting are also known as various types of 'footprints'. Nowadays, these are increasingly used for informing policy makers as well as the public about ongoing environmental [10]–[13] and social problems [14].

CBA requires a comprehensive description of the global socio-economic metabolism including among other the structure of domestic economies, their resource use and efficiency and the amount of trade between countries and regions. Environmentally Extended Multi Regional Input-Output databases (EEMRIO) provide all these data in a consistent framework.

B. EE MRIO databases

1) *EXIOBASE*: EXIOBASE is a global EE MRIO aiming to support analysis of technologies, policies, and standards in relation to EU sustainability policies. The environmental focus of the database is reflected in a high level of detail in the agriculture, energy, mining, transport, and waste management sectors. EXIOBASE provides satellite accounts for over 300 environmental interventions.

The database was developed and analysed in three consecutive EU projects: EXIOPOL [1], CREEA [15] and the ongoing project DESIRE. The currently available version, EXIOBASE 2, implements the economic and environmental accounting principles proposed in the UN System of Economic and Environmental Accounts [16]. The ongoing development of EXIOBASE 3 concentrates on providing a time series of EE MRIOs and now-casting this time series to the current year.

Currently, EXIOBASE consists of EE MRIOs for 27 (28 in the upcoming version 3) EU countries, 16 major economies and 5 rest of world regions in industry by industry (163 sectors) as well as product by product (200 sectors) classification.

2) *OPEN:EU*: OPEN:EU [11], [17] is an MRIO model based on the Global Trade Analysis Project (GTAP - v7) [18] following a method describe by Peters et al. [19]. This MRIO model consists of 94 explicitly modelled countries together with 19 composite rest of the world regions. OPEN:EU was constructed for the base-year 2004.

3) *WIOD*: The World Input Output Database (WIOD) was also constructed as an alternate tool for analysing the effects of globalisation on trade patterns, environmental pressures and socio-economic development on a global level [20]. WIOD consists of a time series (1995–2011) of IOT for 27 EU countries, 13 non-EU countries, and 1 RoW region. WIOD distinguishes 35 industries and 59 products. The WIOD has prioritized aggregate accounts as consistent as possible with official statistics. The database has been used extensively to

analyse fragmentation of supply chains and trade in value added.

4) *Eora*: Eora is a time-series (1990–2011) of input-output tables with high country detail (187 countries and 1 RoW region), utilizing asymmetric levels of detail and concepts of supply-use. There is further a smaller version of Eora at 26 sectors common for all countries. The total database has 15,909 sectors with the size of the system having just over 250 million variables. The database has 35 types of environmental indicators covering air pollution, energy use, greenhouse gas emissions, water use, Ecological Footprint, and Human Appropriation of Net Primary Productivity. A key point of the Eora database is its in-homogenous classification in the full detail version.

II. DEVELOPMENT

Calculation of EE MRIO accounts (Multipliers, Footprints, impacts embodied in trade, etc) followed standard IO methodology. We used the open source tool pymrio (<https://github.com/konstantinstadler/pymrio>) for the calculations.

All results are calculated through input-output analysis (IOA) following classic Leontief demand style modeling. IOA is essentially an allocation of production based impacts (here denoted \mathbf{F}) to the goods and services that flow to final demand (here denoted \mathbf{y}). The allocation starts from the basic production balance, where gross output \mathbf{x} is the sum of total intermediate demand \mathbf{T} (with $\mathbf{1}$ being the summation vector of appropriate size) and final demand.

$$\mathbf{x} = \mathbf{T} * \mathbf{1} + \mathbf{y} \quad (1)$$

Normalising intermediate production (to produce one unit of output, we can calculate the required inputs, giving the technical coefficient matrix \mathbf{A})

$$\mathbf{A} = \mathbf{T} * \mathbf{x}^{-1} \quad (2)$$

Then we can combine the above two equations, using what has been known as the Leontief inverse ($\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$), to estimate the total output (\mathbf{x}) for any given demand \mathbf{y} :

$$\mathbf{x} = \mathbf{L} * \mathbf{y} \quad (3)$$

In MRIO modelling, for a certain demand, in a certain country, the production required to satisfy the demand is calculated. The point of departure from national accounting in gross domestic product terms is that imports are endogenised in the flows of goods to demands, and exports are excluded from a country's demand – in line with gross national expenditure calculations. Environmental inputs or emissions of economic production can be linked to the input-output table through a stressor (environmental intervention) matrix \mathbf{F} . Similar to the basic input-output relationship, environmental intensities (environmental factors per unit production, \mathbf{S}) can than be calculated:

$$\mathbf{S} = \mathbf{F} * \mathbf{x}^{-1} \quad (4)$$

TABLE I

COUNTRIES AND REGIONS OF THE MRIOS INCLUDED IN THE ENVIRONMENTAL FOOTPRINT EXPLORER. THE ORIGINAL COUNTRIES OF THE MRIOS WERE MODIFIED TO HAVE A COMPARABLE COUNTRY SET FOR EACH MRIO. THE NEW SET INCLUDES THE EU COUNTRIES EXCEPT CROATIA (EU27) AND OTHER MAJOR ECONOMIES ACCOUNTING FOR ABOUT 90 OF THE GLOBAL GDP [2]. UN CODES FOR TAIWAN AND THE AGGREGATED RoW ARE NOT AVAILABLE (N.A.).

Number	ISO3 Code	UN Code	Name
1	AUS	36	Australia
2	AUT	40	Austria
3	BEL	56	Belgium
4	BRA	76	Brazil
5	BGR	100	Bulgaria
6	CAN	124	Canada
7	CHN	156	China
8	CYP	196	Cyprus
9	CZE	203	Czech Republic
10	DNK	208	Denmark
11	EST	233	Estonia
12	FIN	246	Finland
13	FRA	250	France
14	DEU	276	Germany
15	GRC	300	Greece
16	HUN	348	Hungary
17	IND	356	India
18	IDN	360	Indonesia
19	IRL	372	Ireland
20	ITA	380	Italy
21	JPN	392	Japan
22	LVA	428	Latvia
23	LTU	440	Lithuania
24	LUX	442	Luxembourg
25	MLT	470	Malta
26	MEX	484	Mexico
27	NLD	528	Netherlands
28	POL	616	Poland
29	PRT	620	Portugal
30	ROM	642	Romania
31	RUS	643	Russia
32	SVK	703	Slovakia
33	SVN	705	Slovenia
34	KOR	410	SouthKorea
35	ESP	724	Spain
36	SWE	752	Sweden
37	TWN	n.a.	Taiwan
38	TUR	792	Turkey
39	GBR	826	United Kingdom
40	USA	840	United States
41	RoW	n.a.	Rest of the World

In order to calculate overall upstream impacts (aka footprints **D**) due to a certain demand **y**, we utilize the Leontief Inverse **L** as per standard input-output analysis:

$$\mathbf{D} = \mathbf{S} * \mathbf{L} * \mathbf{y} \quad (5)$$

Direct emissions of final demand (e.g. gas cooking or fuel consumptions) are handled separately and added to the calculated **D**.

In order to compare the different EE MRIOs included, we aggregated each into the Common Classification System [5]. This system comprises the common denominator for all EE MRIOs available and leads to an aggregation to 41 regions (40 countries and 1 Rest of the World, see Table I) and 17 sectors (see Table II). Due to the European focus of most EE MRIO projects, the Common Classification includes all European Union countries (except the new member state Croatia).

TABLE II

SECTORS OF THE MRIOS INCLUDED IN THE ENVIRONMENTAL FOOTPRINT EXPLORER. THE ORIGINAL CLASSIFICATION OF THE MRIOS WERE AGGREGATED INTO THE COMMON CLASSIFICATION SYSTEM [5] IN ORDER TO MAKE THEM COMPARABLE.

Number	Code	Name
1	AGRF	Agriculture, forestry, hunting, and fisheries
2	MINQ	Mining and quarrying
3	FOOD	Food products, beverages, and tobacco
4	CLTH	Textiles, leather, and wearing apparel
5	WOOD	Wood, paper, and publishing
6	PETC	Petroleum, chemical, and non-metal mineral products
7	METP	Metal and metal products
8	ELMA	Electrical equipment and machinery
9	TREQ	Transport equipment
10	MANF	Manufacturing and recycling
11	ELGW	Electricity, gas and water
12	CNST	Construction
13	TRAD	Trade
14	TRNS	Transport
15	POST	Post and telecommunications
16	BSNS	Financial intermediation and business activities
17	PAEH	Public administration, education, health, recreational, and other services

For the data storage the MySQL RDBMS was used. The results of the calculation which were in csv format files was used to update mysql database table on web server. Wordpress CMS was used for web development. The tool for data exploration was done using wordpress plugin which query data, using php, directly from mysql database table. The data are shown in html table with possibility to select and filter different options and with functionality to export selected data into different formats (csv, pdf, excel). Visualization of data was interpreted using plotly web tool based on d3js.

III. TOOL DESCRIPTION

The interactive database provides three main functionalities:

- 1) Exploring environmental accounts based on a single database
- 2) Comparison of accounts between databases using a common classification system
- 3) Visualization and exporting

We describe these three functions below together with a short example of an use case.

A. Exploring environmental accounts based on a single database

The first choice in the Data Explorer of the Environmental Footprint Explorer allows to specify a certain EE MRIO model. Within one MRIO model, several parameters can be selected (Figure 2), including:

- Base-year
- Stressor (environmental/social) intervention or factor of production, impacts
- Countries/regions
- Sector of the database (industry, product or final demand category)
- Perspective (Footprint, production/territorial accounts, embodied stressors in imports and exports, Multipliers and Intensities)

Based on the selection of the table of accounts gets updated and can be sorted as required (by each column). The length of the table can be adjusted and a search box allows to find entries within the table.

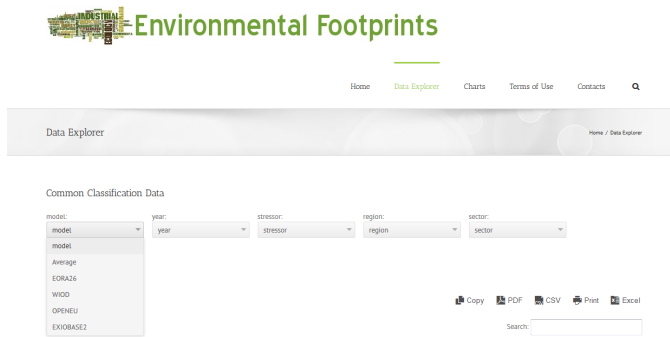


Fig. 2. The Environmental Footprint Explorer aim to ease the data extraction from global EE MRIO databases. Users can select between different databases and specify the perspectives, region and sectors they are interested in.

B. Comparing accounts across databases in a common classification system

The main problem in any EE MRIO comparison is the sector and accounting mismatch between the databases. To solve that issue, we aggregated every database into a Common Classification System [5].

Leaving the model field in the selection unspecified allows to compare results across databases. In addition, we compiled one additional database based on the average results of all included MRIOs. As such, the Environmental Footprints Explorer provides a consistent way to access environmental accounts of different EE MRIO databases and to compare these results across databases.

The implementation of the Environmental Footprints Explorer allows to easily extend the number of EE MRIO databases accessible. In the short term, EXIOBASE 2, WIOD, EORA and OPEN:EU have been integrated. We plan to extend the list of available MRIO as further databases become publicly available.

Some recent studies analyzed the differences between EE MRIO databases [2]–[4]. These studies provided important background information on the reasons of the observed differences and some exemplified comparisons on the effect of the differences of indicators. In order to get the amount of difference for other indicators, any practitioner would need to redo the whole study, starting from parsing several EE MRIO databases, aggregating to a common system and re-analyze the indicator results. The proposed web-platform provides an alternative approach. The comparison of the EE MRIO databases is readily available through the user interface as is the access to the detailed results (Figure 3)..

C. Visualization and exporting

The table view in the Data Explorer provides several possibilities to export the data: The data can be either copies to

Common Classification Data

model: year: stressor: region: sector: parameter:

model: 2007 Greenhouse gas emissions (GWP100 - IPCC, 2007) [kg CO2 eq.] Germany

Total Footprint

Copy PDF CSV Print Excel

Show 25 entries

Search:

model	year	stressor	compartment	region	sector	parameter	value
Average	2007	Greenhouse gas emissions (GWP1...	All	Germany	Total	Footprint	1.54E+12
EORA26	2007	Greenhouse gas emissions (GWP1...	All	Germany	Total	Footprint	1.59E+12
EXIOB...	2007	Greenhouse gas emissions (GWP1...	All	Germany	Total	Footprint	1.59E+12
WIOD	2007	Greenhouse gas emissions (GWP1...	All	Germany	Total	Footprint	1.31E+12

Showing 1 to 4 of 4 entries (filtered from 224,408 total entries)

Fig. 3. Results of a data query are presented as a table, here showing the differences of carbon footprints across MRIO databases for Germany 2007.

clipboard, or exported as excel, csv or pdf file (Figure 3). All export functions work on the currently specified dataset-view.

The Environmental Footprint Explorer provides several interactive visualization functions.

In order to compare total impacts per country, a bar chart can be generated (Figure 4). This chart includes the total amount of impact/stressor for each country and for each specified model. For trends over time, line plots are available. For example, the Green House Gas Emission of China vs USA can be plotted over time for the consumption based (footprint) perspective. Again, this plot can also be used to assess differences between databases (Figure 5).

IV. CONCLUSION AND OUTLOOK

Here we described an integrated web-interface, the Environmental Footprints Explorer, developed to ease the access to EE MRIO results. The platform provides functionality for the in depth exploration of a single database as well as for the comparison across several EE MRIO databases.

Although several EE MRIO have been developed and published in the past couple of years, the use of their results in informing the policy development process has been potentially limited. The reasons for that, are on the one hand, some expertise are needed to calculate indicators based on EE MRIO accounting, and on the other hand due to the often overwhelming amount of data provided by current EE MRIO databases.

Some EE MRIO projects have tried to overcome that problem in the past by providing various kind of open access result reporting. For example, the OPEN:EU projects provides the policy tool EUREAPA to allow easy access to environmental and economic data for an EE MRIO model based on GTAP [21]. The EE MRIO Eora [22] includes a web-interface to access the main results (<http://worldmrio.com>) and the EXIOBASE project provide a booklet summarizing the main results for a policy audience [10]. Similar initiatives exist also on the national level, for example the Open IO-Canada allows to retrieve environmental information based on the Canadian economic input-output tables (<http://ciraigdev.polymtl.ca>). However, all these initiatives fall short in enabling a comparison across databases.

The overall goal of the Environmental Footprints Explorer is to deliver the newest environmental accounting results to

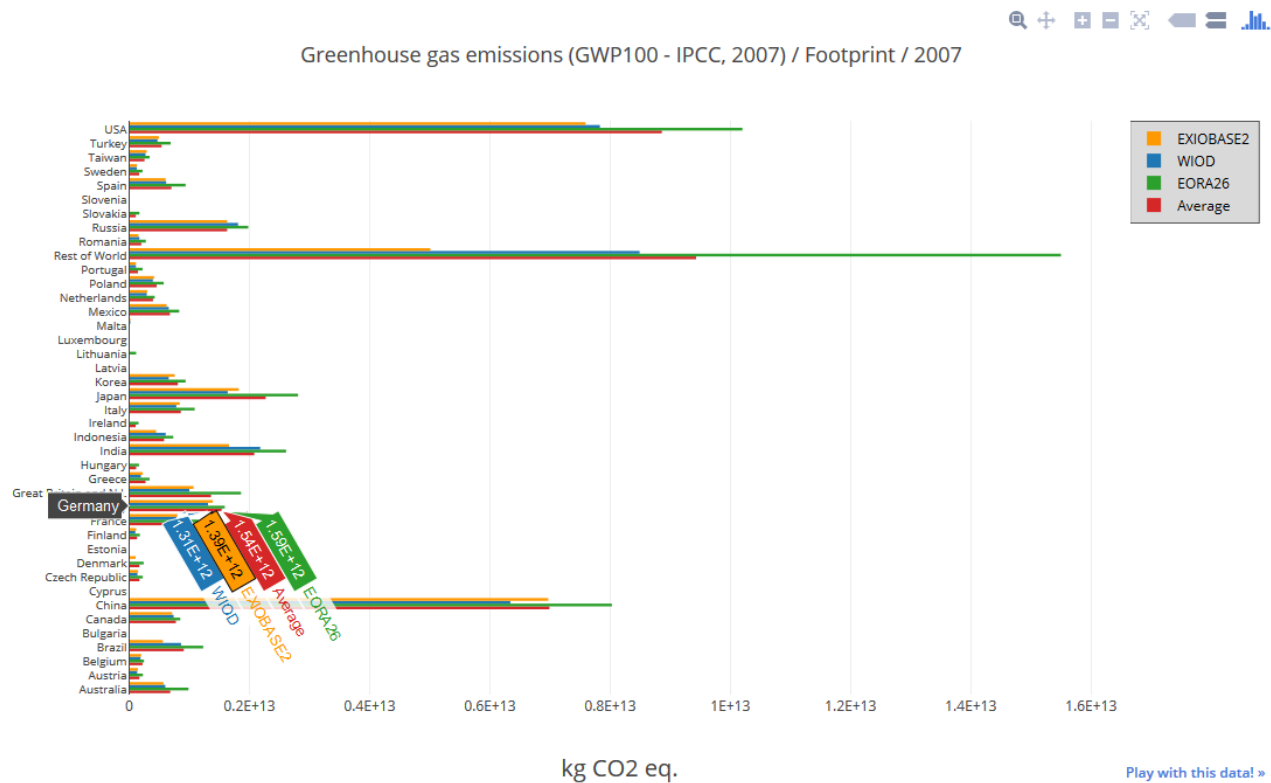


Fig. 4. An automatic visualization procedure provides a quick overview about the extracted data.

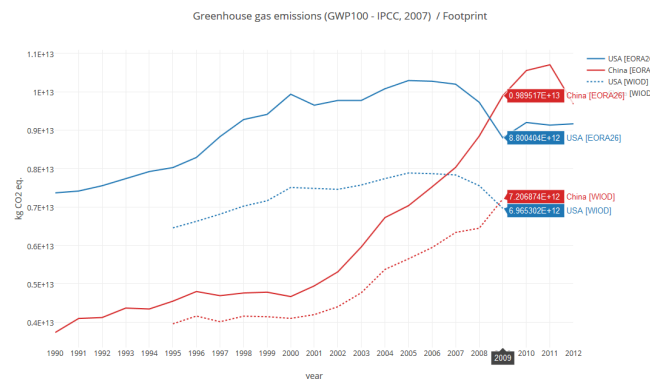


Fig. 5. Comparison of the time course of green house gas emissions between USA (blue) and China (red) for EORA (full) and WIOD (dotted). EORA estimates the overtaking of USA by China in regard to GHG footprints one year before WIOD.

policy makers and the public. Previously, these data was filtered by the analyst of the databases and often restricted to the top level results considered novel enough for a scientific publication. Detailed data or the newest updates of previously published data may still be hidden in the databases, although they could be critical for informing targeting policy development.

Recently, the European Science Policy (<http://ec.europa.eu/programmes/horizon2020/en/h2020-section/open-science-open-access>) as well as various scientific journals [23]–[25] committed to a open science and data scheme. We feel, that, in an ideal situation, open science

should not only provide open access to the raw data used for any analysis, but also provide a way to utilize the data for non-experts. The Environmental Footprints Explorer represents a first step in that direction.

ACKNOWLEDGMENT

This Environmental Footprints Explorer and its contents reflects simple, open-source calculations based on publicly available MRIO databases. A huge amount of work goes into constructing these databases and we would like to thank the scientific groups and consortiums building these databases for adhering to an open science/data framework.

The use of the data included in the Environmental Footprint Explorer means the acceptance of the terms of use of the databases providing this data (OPEN:EU, EXIOBASE, WIOD, EORA). Users are referred to the respective database home-pages for further information. The results presented here are a (near as possible) harmonization of environmental impact categories across the databases. Notwithstanding, results displayed in the Environmental Footprints Explorer platform are based upon these aforementioned databases, but any calculation errors are the responsibility of the developers of this web platform.

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Definition of Social Sustainability Criteria for the Simulation of OHS in Manufacturing Entities

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Abstract— This paper highlights the common factors of social sustainability criteria with economic and environmental criteria for the modelling and simulation of manufacturing entities. Its intended purpose is to demonstrate how and what kind of social criteria can be integrated in such simulation without having to change the model drastically. In addition, the paper presents the prototype of a plugin, as part of a software suite (MILAN), aimed to provide technical analysts with the means to simulate various sustainability criteria in manufacturing companies. The plugin is intended to enable analyst to freely define relevant social influence indicators as well as influence functions and combine them with the existing environmental and economic modeling approach.

Keywords—*Social Sustainability, Sustainability, Discrete Event Simulation (DES), Occupational Health and Safety(OHS)*

I. INTRODUCTION

Aside from the obvious still debated definition problem of social sustainability, which stretches on different modeling levels, it is interesting to note that not many companies will argue about the major influences that social aspects have on their day to day business. The question whether social criteria have an impact on the output of producing companies and how to quantify it, is however more disputed and notably dependent on the company's processes. A consensus on social criteria relevant to more than one company and a software that integrates a resulting social perspective with existing economic and environmental perspectives seems out of reach, thus making holistic sustainability approaches to a real problem.

Considering three simple cases as an example: one company may have ergonomic criteria relevant to their production processes, which they want to have modeled, due to the unknown strain on the workers bodies; another company may have other influences on humans health due to particulate matter exposure and noise; a third may want to elaborate if a simulation study can answer the question if the work organization is beneficial considering the shift management and resulting work load of their individuals. Considering these possible cases the question is: how would the modelling software be designed to represents these very different scenarios, while also acknowledging environmental and economic aspects of the production. This is the problem this paper addresses and will answer by:

- elaborating on the background of social criteria in the manufacturing industry (section III A),
- categorizing the accorded social impacts and deducing criteria for possible simulation studies (section III B and III C),
- referencing the manufacturing simulation software MILAN as basis for the integration (section IV A),
- present the technical concept and the implementation of a software component for the integration of the social perspective in the existing simulation software (section IV B),
- highlight future results and discuss strengths and weaknesses of the approach (section V),
- lastly related work will be presented and an outlook will be given (section VI and VII).

II. THE PROBLEM OF DEFINITION IN MORE DETAIL

In order to formulate a strategy for the evaluation of social criteria it is important to understand how producing companies are motivated to produce in a more (socially and general) sustainable way. Aside from intrinsic motivations of given deciders, the two main theories are legal compliance and the demand of customers, representing top down and bottom up tendencies. For both theories however a variety of limiting factors is applying. The main problem with the top down tendency is that regional and international frameworks, as basis for policy decisions, pay tribute to the different regional necessities, hence reflecting the needs and situation of the people in the region. Ultimately the given diversification results in a different prioritization of criteria, which leads to different compliance criteria for the resident entities. These differences allow for a distortion of competition and consequently to a higher prioritization of the economic orientation in order to keep up with the globalized market. For the bottom up tendency the sphere of activity between the consumer's time and the multiple sustainability criteria (price, environmentally viability, and social friendliness) create conditions that make the necessity for an elaborate research, in order to find a fitting product, to a task that is rarely applicable for all his consummation. While it is fairly easy to assess the economic value behind the chosen product, when it comes to environmental and social identifying values, it is a difficult task. With regard to firms, and particularly manufacturing companies, reports on the sustainability of their operations rarely include the social dimension. Many companies are issuing corporate reports which stress governance aspects and

environmental practices, but, e.g., tend to overlook the role of the employees or workforce [1], [2]. Normally a detailed analysis of products is hard to find and thus, in order to make a decision, consumers rely, for example, on brand identification combined with rather time restricted information on how environmental and social friendly the company is perceived/displays itself to be. In other words, the steering of the capital by the consumer is not based on the actual environmental and social impacts of the product, but by the little information they can gather about the company itself and in elaborate cases its manufacturing processes. The data to assess the environmental and social friendliness of the product itself is not at the consumer's disposition [1]. Naturally a choice regarding the price comes easier than basing the decision on facts that the consumer can hardly evaluate. With this problem in mind, the following sections will evaluate how the social perspective of sustainability can be integrated in simulation approaches in order to contribute social evaluations of products in the future and possibly counteract this problem.

III. SOCIAL SUSTAINABILITY IN THE MANUFACTURING INDUSTRY

A. Understanding social sustainability on company level, definitions, challenges

In the last decades various entities have made great efforts to give deciders a stronger foundation on what social sustainability implies. This section addresses these findings and elaborates the way from a broad perception of sustainability (III A) down to relevant social aspects in manufacturing companies and their orientation (III B), further down to measurable criteria for usage in simulation studies (III C).

Starting with the World Bank's sponsored Social Capital Initiative at the beginning of the millennium [3] many international and regional organizations have since created a variety of international policy/reporting guidelines, such as the G4 guidelines [2] /monitoring/auditing frameworks and other instruments, such as value chain analysis, social impact assessments and other that all aim for a broad perception and integration of social criteria in sustainability assessment. A detailed list of instruments can be found in [4].

When considering these framework approaches and social criteria, the problem arises, that different social criteria will be relevant to different regions, companies and different people. Furthermore, as the sustainability concept has an inherit function to be able to shift in time [5], potential sustainability criteria have to have their qualification flexible in those regards (hinting the change of the model used for their qualification, i.e., iterations of simulations to pay tribute to the change of normative values at the basis of the qualification). In addition to those modeling challenges, Omann and Spangenberg formulated four major challenges on how to assess social sustainability [6], namely:

- the lack of conceptual clarity (emphasizing definitions to be dependent on countries and entities),
- the complexity (questioning if the concept is manageable with current means (org./tech.),

- the "bad experience" from the past (1960's) considering the formulation of normative goals, in order to place social values in relation to the other perspectives, also[7],

- the fact that a stronger integration of social values may question the foundations of development models, cf. [6], reducing the likeliness of acceptance/introduction by deciders.

Many other authors, e.g., [8], [9], argue in similar directions, yet the first argument should not be understood as lack of conceptual clarity but maybe rather adaptability; this is because the regional/organizational shift of relevant criteria is explainable. If we consider social criteria to be in direct relation to human beings, similar to any human need categorization, regional social sustainability frameworks will represent the state of the needs of the people in that region. This does not necessarily influence the validity of existing frameworks, but only reduces their comparability. Summarizing one can observe two essential dispersions that influence the definition of social sustainability criteria in companies, shown in figure 1 and 2 beneath:

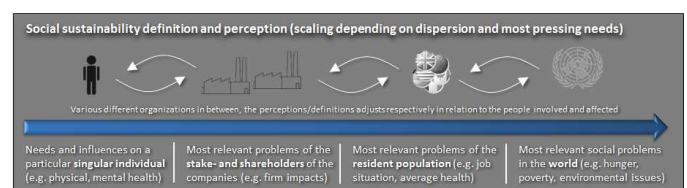


Fig. 1. Scaling of the social sustainability definition depending on the dispersion of pressing needs

The first differentiation needs to be made considering the people and organizations that are at the basis of the question of what is sustainable (i.e. sustainable for whom, for what, for how long). The definition is thus dependent and pays tribute to the different states in which the people or organizations are.



Fig. 2. Scaling of the social sustainability definition depending on people involved and affected

The second variance is in relation to manufacturing companies. It is necessary to make a difference between the social impact manufacturing processes have on the people directly involved in them (i.e. the people working for example at a workstation) and the social influences emitted by the production itself through all their processes, e.g., water usage.

In addition to these differences in definition, the technology choice for evaluation needs has to be addressed. Consequently confronted with a variety of possible input factors the question poses itself, what are the relevant criteria and how could they be integrated. These questions will be answered in the following by first categorizing the various social aspects that are occurring in companies in general and producing companies in specific.

B. Categorization of company based social criteria

The following categorization of social sustainability aspects is oriented on Porter and Kramer's depiction of social impacts

of the value chain of companies [10], [11]. Extending their description of different criteria and placing them in a manufac-

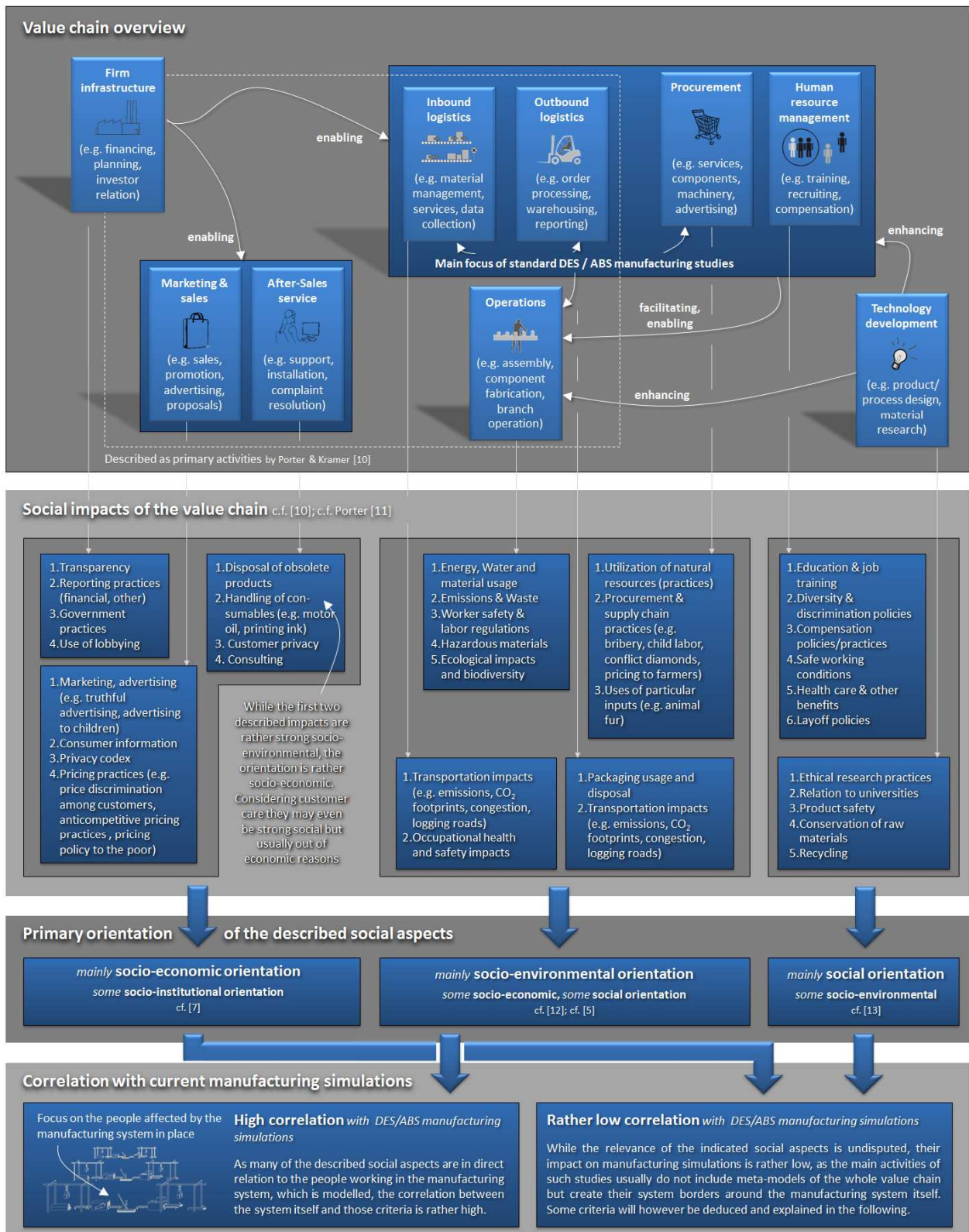


Fig. 3 Social criteria along the value chain and categorization of their impact/orientation, cf. [10]; cf. [11]

turing company's perspective (their elaborations are more general). The main thesis that figure 3 is trying to highlight, is that many of the social impacts at operation's level and generally in the primary value creating activities of manufacturing entities (mainly operations, but also inbound/outbound logistics, procurement) have high correlations with existing discrete event simulation (DES) and agent based simulation (ABS) modeling approaches. This is because the social impacts are mostly directly linked to either the materials in usage (socio-environmental orientation and socio-economic if we consider efficiency aspects) or the people working and facilitating the functioning of the workstations (social orientation, occupational health and safety (OHS)).

C. Definition of social criteria relevant to the simulation of manufacturing companies

One can thus note, that a limited integration of a social perspective in existing economic, environmental orientated manufacturing simulation models is possible without having to change the model itself drastically, opening the possibility for a more integrated holistic modeling approach. In that regard the choice for a first set of resulting criteria was based on the described social impact criteria from these aspects (OHS and material/substance interaction, physical exterior influence exposure). Also note, that the indicated social impacts are naturally not complete, further elaborations of social impacts at midpoint level can be found in [14]; the given figure was intended to demonstrate groups of impact criteria and their categorization. Furthermore, as these have been categorized as socio-environmental, basically representing the original sustainability perception of conservation, and as socio-economic, the correlations between the pillars of sustainability should become even more apparent.

While this only considers a limited view on social impacts (reducing the perception to the manufacturing processes), it is important to note, that the life cycle approach can consequently be incorporated through the integration of social life cycle assessment (SLCA) data for the materials in usage and general upstream input data. To clarify this, consider a classical manufacturing model, which depicts the system borders at the in- and output flows before and after the existing manufacturing processes. This model has and produces little life cycle knowledge but only considers the manufacturing aspects (which depending on the used materials make more or less of the overall impact). It is however possible to have a combination of classical DES/ABS manufacturing approaches in combination with life cycle assessment (LCA) upstream data (and possibly even downstream data, depending on the modeling approach), as has been demonstrated among others by [15], [16] and [17] for the environmental LCA (ELCA) part. Taking SLCA parallel to ELCA, it can thus potentially be used for two different overall purposes, already discussed in 1997:

- to compare the social impacts of two comparable products or services (or compare a product or service against a standard),
- to identify hot spots or improvement potentials in the life cycle of the product or service.

There are different approaches, which use different simulation techniques in order to model and simulate the bigger picture (apart from the LCA integration), i.e. changes in customer demand (due to marketing for example) or the abstract term of innovation (tech. dev.) can be modeled and simulated using system dynamics, examples can be found in [18], [19], [20] and then combinations of these can be found in [21] and [22] using also LCA.

Since the integration of social issues into LCA, SLCA methodology now advanced to the point where it is left with many of the same unresolved issues as ELCA [23]. These include:

- the challenges of tracking down site-specific data,
- the challenges of integrating location sensitive information,
- the challenges of integrating information collected at different scale (from general sectors to specific unit processes),
- developing characterization methods [4].

Yet, even though the data situation is always a problem to be taken seriously, the concept of integrating social impacts for the production processes in the simulation model, as was already done for environmental criteria, while integrating social impacts for the different other life cycle stages through SLCA data, was found worthwhile and is at the basis of the depicted prototype that will be elaborated in the following.

IV. INTEGRATION OF SOCIAL SUSTAINABILITY CRITERIA IN THE DES/MFA/LCA SIMULATION SOFTWARE

A. The basics of the simulation software MILAN

The software MILAN has its origin in 2001, when the conviction began, that the combination of material flow analysis (MFA) with existing simulation approaches was worthwhile [24].

The concept of combining discrete event simulation and material flow analysis in a component-based approach was then presented in 2006 [25] and its re-implementation on .NET basis was elaborated in 2009 [26]. The integration of DES with the material flow perspective of MFA within a single integrated modeling approach was made possible in order to strengthen the perception of correlations between environmental and economic questions. Based on the dynamic, tactic and strategic character of the simulation approach itself, the perception of material and energy flows, which was at that point not part of the operative level, was intended to be given a more strategic, proactive tendency.

In 2011, a capital measurement approach for a more holistic sustainability perspective was presented, hinting the beginning of the integration of the life cycle approach [5].

In 2012, the ELCA integration was elaborated and the integration of the social perspective was discussed in the outlook [15]. Since then the simulation software has constantly been enhanced with new features and has been used for case studies with companies in Germany and Switzerland (under a

different scope (EcoFactory) with a MILAN core). The most basic components of the software are:

- a simulation core (central simulation service, interfaces and abstract base classes for models),
- a bundle for discrete event simulation (specific for DES, with scheduler, timing aspects, etc.),
- stochastic distributions (e.g., Bernoulli, Exponential, etc., to generate streams of numbers),
- a graph editor (enabling the visual representation and manipulation of models),
- property editors (facilitating the parameterization of model entities and given metadata),
- a reporting suite (creating the simulation results and preparing charts depending on the scope),
- the material management (for the creation, management of materials, batches, bills of materials),
- the material accounting (by its means it is possible to show, save and manage material and energy bookkeeping resulting from the simulation. The bookkeeping is realized using accounting rules, which can be added to all discrete events in combination with relevant model components),
- a LCA browser, which enables an easy, string-based search and the subsequently integration of LCA material data, enabling life cycle inventory (LCI) and LCA in the simulation and the results.

For more information about the technical aspects of the simulation software, see [26].

B. The social perspective prototype

When the social prototype was first designed the two attributes found to be the most important were:

The component architecture: aside from normal component-development reasons, such as high reusability and the easier understanding of the code, through clear, small packages, this also states, that the usage of the social perspective is not enforced, i.e. it is possible to model social aspects through the software, but one does not have to. The software also allows to only build DES simulation models and not integrating MFA or LCA, but if the data is existing and the intention is to have a strong, holistic model, one can use the different techniques combined in one modeling approach and only a single model has to be created, incorporating the methodologies.

The free definition of influences: this is based on the conviction that social criteria, as well as their measurement, are still very disputed. Based on this, it was decided that an open definition of different influences would be made possible, with different editors for the most common influences (physical, organizational, psychological), incorporating current knowledge considering the measurement of such criteria and their impact on human resources over time. These impacts however are not validated by the tool itself, i.e. the reasonableness of the defined influences and their impact lays

currently with the modeler (except for logically excluding behavior).

The main features of the social component will be elaborated in the following (Figure 4 shows a highly abstracted/simplified illustration of the major components of the new domain for the social criteria):



Fig. 4. Main components of the social criteria domain and correlated elements

Human resource management/editor: based on normal resource management approaches a functionality was created to split existing resources into three different resource types, 1) human resources, 2) tools and 3) usable resources. Each of these resource types has a different editor, facilitating for the human resources possibilities to adjust for skill set, integration of distributions considering illness or weaknesses (also usable for the modeling of elderly workers and adjustment of strengths in the following) and many others. Furthermore a new pooling mechanism was created based on a list of categories attributable to the existing resources, for example one could attribute a human resource different locations, workplaces and others (also at different time steps). The categorization/pooling then manages for example the availability of the resource.

Shift management module: the shift management is basically a standard shift planning tool that is used for both, the workstations, i.e. one can define if production processes are continuously or with breaks for a period of time. This is of course relevant for the warm up phases and different states of the workstations. Furthermore the shift management is used to attribute different human resources to their respective work-related entities. These could be different workplaces (although a workplace editor is yet to be integrated). For the moment these are the respective workstations (i.e. the rather classic DES workstations model entities). In that regard a classical resource usage over time can be calculated and attributed to locations as well as workstations and other categories that were defined in the resource categorization. In addition the possibility is given to attribute a type of influence on the resource over time. These possible strains can be either physical, or otherwise, depending on the modeled influences through the different influence editors and the following choice of the modeler.

Social influence layer: in this layer, different editors for different types of influences were developed, the main differentiation is between physical, psychological and organizational influences, where the physical editor guides the definition of a physical influence through possible input choices (strong relation to German OHS guidelines, as in strains for lifting, crouching, carrying, but also general, as in workload dependent, biological interaction, noise, etc.) all of

the possible choices are backed up with known formulas for the development of the influence (such as the physical basics of noise development or basics for the development of particulate matter in production processes), as well as known limit values considering the strain on an average human being. The psychological editor does currently have a completely free definition of influences, while different types are suggested, no choices of formulas is, but rather the definition of a type is mandatory, which can subsequently be used in the rule set editor. The same procedure is implemented for the organizational influences. Even though many studies were incorporated in a knowledge basis for these components (a systematic review of occupational musculoskeletal and mental health studies for production systems can be found in [27], the definition of the non-physical influences was implemented without structural restriction.

Human environmental influences rule set component: this is the second key element for the integration of the social criteria. In this element one can choose from the previously defined social influences and by the usage of a math expression parser and the existing model of shifts and or the production system (i.e. the workstations), combine time with influences to create an impact over time. Different dose concepts were evaluated in that regard, which are also integrated in a knowledge base and selectable (note: the tool is only making a basic validation for reasonable combination choices). Once an influence is attributed to a shift or a workstation, the simulation is then calculating an impact of the indicated influence over time.

V. RESULTS AND DISCUSSION OF STRENGTH AND WEAKNESSES

The social component is currently being tested in two use cases, respectively in one plastic processing company and one company that is creating technical boilers. Aside from the classic results, such as new information on resource usage, failure times, etc. new information considering workload and strains on human resources are expected as results. Different scenarios are still under evaluation (noise, repetition, material exposure influences). What can however be observed, is that the bringing into focus of social aspects, already created ripple effects, considering the perception and the management of social impacts.

In light of the current feedback, we argue that the main weaknesses/challenges of this approach (bad data situation, privacy issues, fear of abuse, wrong evaluations) are manageable and that it is similar as with the environmental sustainability assessment in the past, i.e. that the best way to address the complexity is by making one step at a time, without losing focus of the needed flexibility and adaptability of further models, simulations and their result qualification. This approach is intending to do just that. While others have shown that different social aspects can be integrated in DES manufacturing approaches, it is our intention to create the scientific basis for the step by step integration of new impact criteria, by delivering results of successful integration and evaluation of social criteria through the depicted method in the future. The concept for a worthwhile integration of SLCA criteria is currently being worked on.

VI. RELATED WORK

A. *Classical perspective on manufacturing systems and their simulation*

The classical usages of simulation considering the economical perspective of manufacturing systems and its rather output oriented point of view have already been discussed in much detail, examples from a discrete event simulation approach can be found in [28]. In [29] recent advances on key technologies for innovative manufacturing are discussed. In the same regard, a general review on supply chain performance measures/metrics can be found in [30].

B. *Combination of different perspectives (i.e. environmental, social, economic) in simulation*

Over the last decade the environmental perspective has become more prominent, examples for the focus on the environmental sustainability of production systems can be found in [31], [22] and [32]. In [33] one can find a list of simulation tools with a status overview of their features considering sustainability aspects, furthermore material and energy flow data are under observation in [34]. Most existing simulation software is not integrating the life cycle approach. It seems that the perception of the system borders of the simulation approach, which logically inhibits the gate to gate focus is hindering the other. In order to change that and integrate upstream data, two strategies can be observed: on the one hand, through the integration of LCA data (for used material) at least the environmental and some social aspects of the downstream can be integrated, examples in [16] and [22], while on the other hand different simulation techniques (for example DES and SD and or ABS) are combined in order to model and integrate different parts of the life cycle in appropriate and possible detail/granulation. These will logically be integrated once the simulation has finished see for example [17]. The combination of these different models is however usually happening via interfaces not integrated in a single model, while [5] and [15] depict the integration of LCA and DES in one modeling approach.

C. *Social criteria and OHS in simulation of manufacturing systems*

Social criteria are only very rarely considered when considering the sustainability of manufacturing system in general [35], [1] and when it comes to the simulation of these even less. In [36] ergonomic criteria are, as part of the social domain, integrated in one simulation approach; [37] displays the results in more detail. In [38] stress at the workplace is analyzed and ergonomic workstation factors categorized. Implications towards the work performance of following measures can be found under [39]. Detailed analysis of occupational musculoskeletal and mental health with specific focus on production systems can be found in [27], they also show an overview over relevant studies as well as highlight the significance of the findings of these studies. The European Agency for Safety and Health at Work Report 2013 is also highlighting OSH risk and trends [40]. A detailed analysis of

historic occupational safety measures and trends can be found in [41]. Examples and guidelines for shift-management/workplace fatigue can be found in [42]. In [43] a case study about a conceptual framework for the improvement of business performance with lean manufacturing and human factors interventions is given. In Germany a new guideline by the association of German engineers has been published, depicting the representation and physical strains on humans in virtually modeled manufacturing halls, an analysis is described in [44]. Lastly [45] are making suggestions for systematic workplace/assembly redesign for aging workforces.

D. Capital approach, (social) sustainability assessment and SLCA

Aside from the already mentioned summaries of the Social Capital Initiative [3] and [46], more holistic approaches considering social sustainability can be found in [6]. The capital approach for sustainability evaluation is explained in chapter v. of [47], which is relevant for framework compositions. Social capital in relation to quality of life is discussed in [48], productivity in [49].

When talking about holistic sustainability approaches one should consider [50], where the authors find many good arguments against the reductionist approach. Another holistic perception sustainability design approach can be found under [51]. In [35] one can find a good example of breaking down criteria from a macro management oriented (OECD – Sustainable Development) perspective, to social criteria in firms (see also [7]). Further extensive reviews of social sustainability can be found in [8]. A literature review of social sustainability assessment methodologies can be found in [4], this paper is also very valuable considering LCA integration and possible SLCA adaptations. Considering SLCA, one has to note author Jørgensen, who published many excellent papers [14] for example on the integration of SLCA criteria in companies, summaries of his work are in [23].

VII. CONCLUSION AND OUTLOOK

Last year's Amnesty International Report [52], titled "the dark side of migration" was discussing the exploitation of humans as workforce under inhuman conditions. While this very terrifying problem is less occurring in western countries, it is common sense, that as long we cannot track and measure the social impacts of production processes, it is less likely that consumers will be empowered to choose social friendly created products, and hence not be able to steer their capital accordingly.

Even though we agree with the conclusion of Gasparatos et al. [50] considering methodological pluralism (very simplified: more is not necessarily better), the key idea of the approach in this paper is the attempt of the integration and ability to put different perspectives in correlation. It is clear that the social aspects have yet to mature in their scientific provability, yet potentials can clearly already be indicated. This is what the tool already delivers as result, potentials compared to limit values (i.e. elevated by x%, without qualifying beyond stating that it is a positive or negative tendency and putting it into context).

The main arguments against the integration of social criteria are usually their fuzziness and the fact that every human is different. These points are valid; however the main aspects of human beings are not so different as a variety of studies suggest [27]. Of course it is complicated to derive exact numbers, but that is where the free definition of influences comes into play, by allowing for the modelling of workers, as well as the impact on different levels. So while the presented approach is far from scientifically established, its purpose is more to promote the re-integration of social values in existing manufacturing processes. Human development author and activist Max-Neef mentioned in his keynote at Zermatt Summit 2012 that sustainability has been misused to promote rather economical concepts than actually bringing the essence of what sustainability incorporates into prominence, hence it is the intention of this paper to clarify that the deficit of social integration in these regards can be overcome.

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Dredged Sediments, Web-GIS and Analysis Tools – The CEAMaS case study

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Abstract. Spatial analytical techniques are commonly used to inform critical aspects of dredging operations, providing powerful decision-making capacity when used with appropriate datasets. Geographical Information Systems (GIS) provide an operational framework within which a variety of dredging-relevant geospatial tools can be implemented. These may be generic or specific to particular dredging operations, in the latter case producing data for large numbers of relatively discrete dredging zones or operations. Pooling and cataloguing these individual operations can create a rich set of resources (data and tools) of value to decision makers, not only for use in managing dredging operations but also, to support the potential reuse of the material and the treatment needed for the use of the dredged material (DM). Web-based GIS are an ideal medium for displaying inputs required to complete spatial analyses, providing decision makers with an easy-access tool for use in combining information to optimise decisions. The early adoption of web-GIS technologies during the initial planning phase of a dredging process can lead to improved outcomes. Not only are end-users furnished with a more comprehensive view of the spatial aspects of a project but actual rates of sediment re-use may be increased through the provision of access to efficient tools with which to readily examine a selected set of high potential re-use options.

Keywords: *GIS; Dredged Material; Decision Support System; Smart Atlas; Catalogue*

I. INTRODUCTION

Dredging operations are frequently undertaken in order to adapt the physical geomorphology of the environment to meet specific sectorial requirements e.g. ports and shipping. In the context of coastal processes, the extraction of sediment as a means of adapting the marine environment for economic reasons can have far reaching consequences both offshore and onshore. 'Dredging is essential to maintaining navigable access to Ireland's main ports and harbours which account for 99% of Ireland's imports and exports by volume and 95% by value' [15].

Dredged material (DM) arising from such activities has commonly been considered as waste, however advances in technology and the increases in possible reuse options for marine sediments in a variety of civil engineering applications, frequently necessitate detailed case-by-case investigative studies to be carried out for operations where reuse of DM is intended.

The tools for analysing the specific of individual cases have also evolved with improvements in technology, and in some occasions, the adoption of tools from other fields of research to offer new perspectives to dredging studies; for instance, GIS tools and technologies. The geographical record of sediment

relocation operations, dredging and reuse, is clearly better handled by a GIS. Whilst such spatial inventories are valuable and help to create a clear picture of the processes under investigation, the more advanced spatial analytical tools in a desktop GIS can be used to help identify where the reuse of sediments can match land use requirements.

The EU project CEAMaS (Civil Engineering Applications for Marine Sediments) provides a suitable work programme within which to test the potential of GIS tools for dredging and sediment recycling activities. The main aim of the project is to establish a uniform framework for the beneficial reuse of sediments at European-Level. The project is also reviewing the legal and policy frameworks from the different country members in order to encourage progress towards a more harmonized regulatory framework for the beneficial reuse of the sediments across all the member states. Several tools are under development through the project for enhancing decision making processes for dredging European dredging operations including: a bibliography, catalogue, uniform list of potential sediments for reuse and web-GIS tool.

The web-GIS tool created by the CEAMaS team (from now, the Web-GIS) provides an interactive graphical user interface which has been designed to facilitate decision support. The selection of layers displayed on the map is configured so as to facilitate decision making in specific contexts e.g. the identification of the areas where dredged may be required, the potential locations where sediments may be reused, and all the factors relevant to intermediate process steps such as transportation routes, civil engineering industries, dumping areas or sediments storage facilities. All the phases in the reuse of DM can be simulated, from the initial planning of the dredge campaign, until the final end-use of the DM.

Web-GIS tools are relatively intuitive in use with underlying modular designs providing the inherent functionality that can be rapidly adapted to suit specific requirements. The information displayed can be consulted, merged or printed, enabling the desired information to be compiled into maps or reports, which can be integrated in publications. The web-GIS maps also work as a catalogue database, allowing other services and users to import the information into their own environment through a WMS link.

II. STATE OF THE ART

Several GIS application tools are available on the web. The representation of any type of information in a geographical way, helps to contextualize the inputs available for any economical practice.

MapServer is an Open Source platform for publishing spatial data and interactive mapping applications to the web. Originally developed in the mid-1990's at the University of Minnesota, MapServer is released under an MIT-style license, and runs on

all major platforms (Windows, Linux, and Mac OS X). It is not a full-featured GIS system, nor does it aspire to be.

Smart Atlas is developed in-house by Beaufort UCC and is an “atlas in a box” that is easy to deploy and customise. It allows users to publish maps on the web in an easy way. Smart Atlas relies on UMN MapServer’s MapScript as a server side. It has a web graphical user interface developed using GeoExt and ExtJS. Many smart atlases were created using this technology: ie, the International Coastal Atlas Network (ICAN), Irish Coast Guard or ODINAFRICA.

The CEAMaS project has developed a Smart Atlas based on open source technology, which means that it can be adapted for the end users’ needs if necessary. The Smart Atlas is a web-enabled GIS map based catalogue and tool kit developed specifically for this project (see section III-C)

Additionally, the data represented in the survey needs to reflect the typology of the sediments from the different sampling sites. This approach will drive the characterization of the DM, identifying the physical properties materials present in the target areas, and secondly identifying their chemical properties, including the presence of contaminants. The treatment options for using the sediments for any specific operation will be strongly influenced by costs involved. Figure 1 gives an overview of the main factors to be considered in deliberations on the fate of DM.

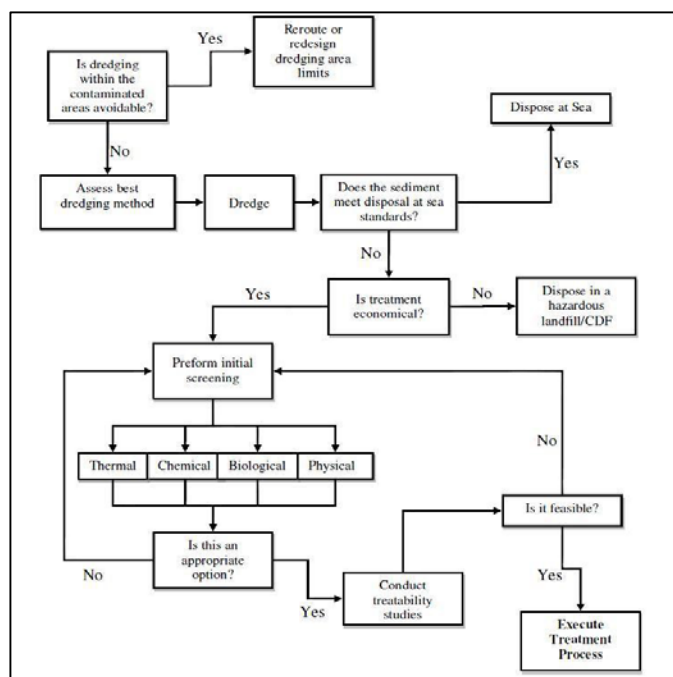


Figure 1. Treatment decision tree designed by USEPA (1993) [17]

The costs, both direct and indirect, would affect the decision process first, and secondly, the actions required to reach any of the goal in a dredging project. The simplification of the tables through a geographical view can makes from the process something more accessible to all the users.

III. METHODOLOGY

A. CEAMaS

‘Civil Engineering Applications for Marine Sediments’, also known by the acronym CEAMaS, is a transnational cooperation promoted through EU funding to encourage knowledge and consensus to raise new solutions for the reuse of marine sediments applicable across Europe (<http://www.ceamas.eu>).

The main aim of the project is to promote the beneficial re-use of marine sediments in civil engineering applications, in a sustainable, economical and socially acceptable manner.

As normalities, regulations, assessment criteria related to sediment management differ in each country, due to local regulations and standards, the project partners are making as one of the goals the identification, compilation and analysis information (technical, economical, regulatory, environmental and social), bibliographies, practices, options and solutions available in North-West European countries in order to better understand and evaluate the perspectives for the reuse of dredged marine sediments in civil engineering practices in Europe.

The geographical scope of the investigation and analyses will cover Ireland, UK, the Netherlands, Germany, France, and Belgium using the expertise available in University College Cork (IRE), Cork Institute of Technology (IRE), Delft University of Technology (NL), cd2e (FR) and Belgium Building Research Institute (BE).

Following the main lines of the project, CEAMaS will clarify and foster convergence between European and national legal frameworks for dredged sediment management and will bring perspectives for the reuse of marine sediments in civil engineering application in Europe.

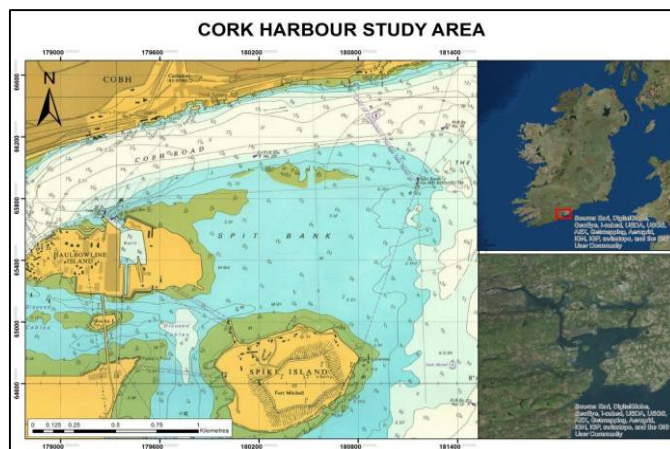
As part of the initial CEAMaS output, some tools will be published by summer 2015:

- Online multi-criteria decision-making tool,
- Online training platform,
- Online Data Base,
- Online documents, studies & bibliography,
- Online (Web) GIS

The deliverables will be made available in an online format in order to improve availability of the tools and encourage their widespread adoption.

B. Spatial Analysis and GIS database

To strategically focus effort, CEAMaS will develop two detailed study cases for dredged material reuse: Cork Harbour (Ireland) and Nord Pas du Calais (France). The accessibility of information available to CEAMaS makes these two study cases ideal demonstrations for the Smart Atlas functionalities. Whilst localized, these examples demonstrate inherent capabilities which are expected to be broadly applicable across a diversity of dredging operations (Figure 2).



informed decision making.

The toolset provided through a GIS, facilitates the processing of information, and the display of data spatially, both in 2D and 3D, highlighting relevant geospatial information through easily accessible data in the form of shapefiles. (Figure 3)

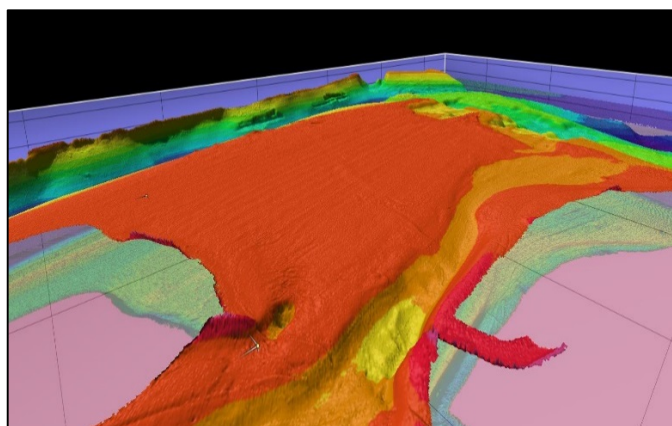


Figure 3. Visualization in 3D of the bathymetric data for a part of Cork Harbour

In order to undertake dredging activity responsibly, it is necessary to characterise the target sediments. Combining data from acoustic sources e.g sub-bottom profilers, multibeam echosounders, with results of physical site investigation techniques (coring, grab samples) etc., using spatial analytical and geostatistical techniques can produce an integrated volumetric map of the target area in which the variations in sediment properties are well delineated. (Figure 4)

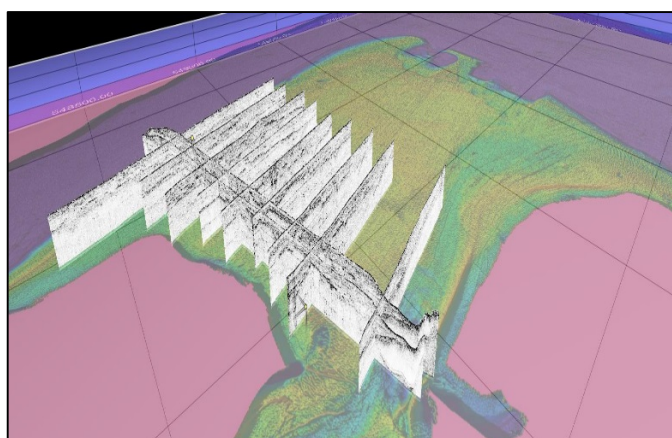


Figure 4. Visualization of the seismic data fence diagrams undelain by bathymetric coverage for a part of Cork Harbour

GIS analyses for manipulating and integrating geophysical datasets have been commonly used by the industry for many years. The outputs collected from these types of analyses can be aggregated and stored in a catalogue to facilitate the compilation of further datasets to enable an interpretation of site dynamics of key benefit to end users.

One of the main goals proposed by CEAMaS is to feed the compilation of all the GIS products in an online catalogue directly to the European Resources Centre (ERC) (see below). This **spatial catalogue** should become a primary source of consultation for any decision maker, who will be able to appraise themselves of previous stages the dredging activity relevant to future planning. This data should be reinforced with proper metadata following ISO standards, with the process outlined in Figure 5 used to compile and create the datasets.

Ireland Ports	
Reference system information Identification information Distribution information Data quality information	
MD_Metadata: File identifier: Character string: uc2b66-376d-4938-9a66-c4a43007012 Language: gmd:LanguageCode: (codeList: http://www.isn.gov:metdata/uc2b66-376d-4938-9a66-c4a43007012) Character set: MD_CharacterSetCode: (codeList: http://www.isn.gov:metdata/uc2b66-376d-4938-9a66-c4a43007012) Metadata author: CT_ResponsibilityParty: Individual name: Character string: David Rugg Organisation name:	

Figure 5. Html metadata visualisation on the WebGIS

C. Web-GIS

Here, we define the Smart Atlas as : an online mapping application (web-GIS) that displays relevant information (mainly geo-data) about a specific topic, whilst offering users some of the standard toolsets and functionality provided by a desktop GIS, i.e. zoom, polygon drawing, pan, select, printing, etc., highlighted in the figure 6. The application enables online viewing of geo-data.

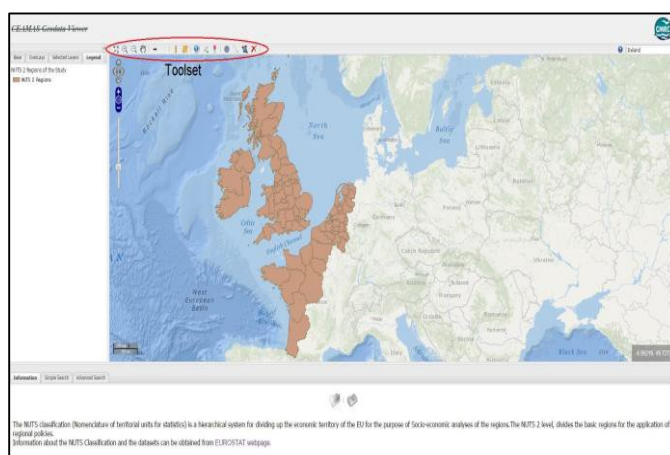


Figure 6. Toolset available in the geodataviewer

The CEAMaS geodataviewer has been implemented using open source software technology. The user interface is accessible from most web browsers. Online dynamic querying and visualization functions are driven by the MapServer web-based mapping system. Information pertaining to the layers displayed is also easily accessible.

For every dataset, a quality informative metadata is displayed compliant to ISO 19115 standard. Descriptive information on geo-spatial data including origin, quality, geographical extent, etc., pertains to individual features as well as hosting links to a range of additional non-spatial reference materials such as pdf files, graphics, or related reports. Data layers are organized and served over the internet using Mapserver (WMS standards compliant).

The figure 7 shows the architecture behind the information displayed in the web-GIS. All the functionalities are divided and processed through a central server, making of the main webpage a user friendly interface, accessible to all type of costumers.

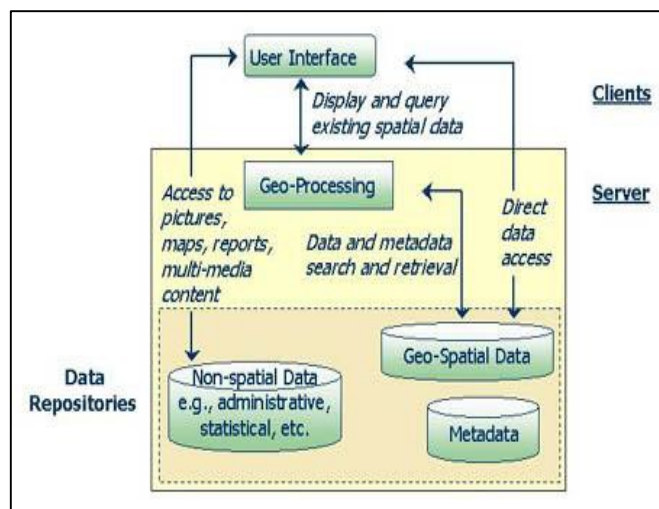


Figure 7. Elements that make up the CEAMaS geodatabase system

Content for the geospatial information layers (shapefiles) has been built from publicly available sources fused with newly acquired data in order to deliver information at different zoom levels (three tiers) from individual ports up to regional scale transport networks.

As outlined above, the web-GIS built with the smart atlas technology, is not a GIS substitute, so the datasets displayed have to be 'pre-cooked' with desktop software before being uploaded to the web through the server. A similar process is needed for non-spatial data which can be introduced to the server and then linked to the spatial data.

D. DM use – Decision Support System tool

'DM can be considered as a valuable resource; a useful source of granulate material if properly handled and applied in a beneficial manner. Such beneficial use of DM, may significantly reduce the environmental impacts associated with the disposal of the DM and may reduce project costs with the potential added benefit of re-using a material which has traditionally in many cases been considered to be a waste material' [8].

The data displayed on the web-GIS provides a local to regional context for the case studies. In combination, the data introduced and tools provided, enable end users to initiate an analytical procedure relevant to dredge planning in the area of interest. Once the dredging decision is taken, it is often necessary to consider the possibility of reusing the DM for an alternative purpose or find locations for storing it. Use of the web-GIS can facilitate this part of the overall dredge spoil management procedure.

The first step is the characterization of the potential DM. To enable this, sufficient sediment samples from the proposed dredge site must be collected, tested and analysed. 'DM properties are site specific hence the importance of developing independent surveying and sampling plans for a specific dredging project. These may vary according to the nature and perceived sensitivity of the environment, the volume and area to be dredged, and the need to address other activities nearby' [1]. The sampling should also be representative of the size and depth of the area to be dredged.

Deciding the ultimate destination in terms of where the sediments maybe economically transported to, often represents a key issue in any decision process. Small increments in this variable can greatly increase project overall costs, with the potential to jeopardize overall economic feasibility. Promising locations can be identified using spatial multi-ring buffering techniques, around potential sediment discharge sites. This approach simplifies cost quantification DM transport,

irrespective of whether material is destined for a treatment plant or storage location.

The Decision Support System (DSS) tool described in Mason, E. et al [16], enables the creation of an inclusion/exclusion buffer through calculating the Euclidean Distance from the dataset, which highlights the more suitable and unsuitable sites for the placement of any action as it could be a treatment plant. The creation of areas of influence or constraints, creates a positive or negative constraint, indicating the interest of the user in having the DM deployment site closer from any data point. (Figure 8).

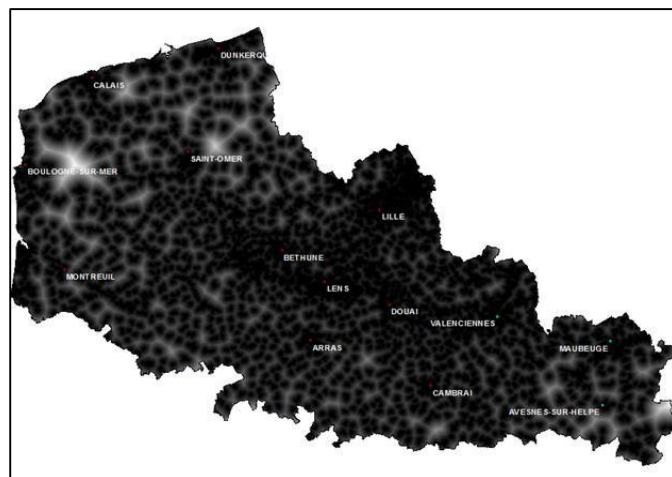


Figure 8. DSS tool, positive constraints analysis for the Nord-Pas-de-Calais region (France)

To create a multi-criteria tool, it would be needed to cross all the constraints and made the calculations with a corrector multiplier for every single data, implying the interest of the user in every dataset. For that, all the information should be normalized using a distance factor:

$$RastDistNorm = \frac{(RastDist)}{DistMax}$$

$$InvRastDistNorm = \frac{(RastDist - DistMax)}{DistMax} \times -1$$

By excluding the spaces where sites cannot be build and, at the same moment, remarking the places where any action with the sediments are more likely to happen, the decision makers will have an extra-aid in the process, highlighting the availability of spaces in the region. The duality of the dataset as positive/negative constraint gives to the end users the flexibility to prioritize some locations above the others. These datasets from the DSS area are created with spatial analysis toolsets from a desktop GIS, and eventually can be exported to a web-GIS, making from the information available, a very accessible tool for any user.

Every case study requires a different approach due to the unique characteristics that every local region has, i.e. transport, natural protection, etc. As it is highlighted previously, in the CEAMaS project lifetime, only will be studied in detail the cases from Cork (plus the region of Munster) and Dunkerque (plus the region of Nord-Pas-de-Calais).

The import of the datasets created following the Spatial DSS into the web-GIS, would recreate different variables in the process, showing all the hypothetical solutions for the DM deployment and transportation.

The web-GIS could be a supporting tool at any stage, but also

in later stages, as has been seen with the transport issue. The spatial analysis of coastal dynamics might indicate where the sediments are going to be needed in the future.

Having available DM suitability based on sediment characterisation (Figure 9) the approach shows which type of material is needed, highlighting on a map the treatment necessary to adapt the dredged material for the re-use.

		DM Suitability based on Characterisation								
Category of Beneficial Use	Type of Beneficial Use	Uncontaminated	Contaminated	Freshwater	Saltwater	Soft Clay	Silt - Soft Clay	Sand - Silt	Consolidated Clay	Gravel-Sand
Engineering Uses	Beach Nourishment	✓	✗	✓	✓	✗	✗	✗	✗	✓
	Land Reclamation	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Landfill Cover	✓	✓	✓	✓	✓	✓	✗	✗	✗
	Offshore Berm Creation	✓	✗	✓	✓	✓	✓	✓	✓	✓
	Coastal Protection Works	✓	✓	✓	✓	✗	✗	✓	✓	✓
Environmental Enhancement	Wetland Habitat Creation/Enhancement	✓	✗	✓	✓	✓	✓	✓	✓	✗
	Sediment Cell Maintenance	✓	✗	✓	✓	✗	✓	✓	✓	✗
	Fill for Abandoned Mines/Quarries	✓	✓	✓	✓	✓	✓	✗	✗	✗
	Upland Habitat Restoration/Creation	✓	✗	✗	✓	✓	✓	✓	✓	✓
Agricultural / Product Uses	Concrete Manufacture	✓	✓	✓	✗	✓	✓	✗	✓	✗
	Road Sub-base Construction	✓	✓	✓	✗	✗	✓	✓	✓	✗
	Landfill Liner	✓	✓	✓	✗	✓	✗	✓	✗	✗
	Manufactured Topsoil (MS)	✓	✓	✗	✓	✓	✓	✗	✗	✗
	Production of Ceramics/Bricks	✓	✓	✓	✓	✗	✓	✓	✗	✗

Figure 9. Beneficial use options for DM [12]

IV. CONCLUSION

The use of the spatial analysis is a common practice in the appraising dredged material operations. Thus, the extension of this type of studies to a web-GIS is a logical consequence. The integral DM use study, from the very first idea of dredging until the moment of reused in a civil engineering application, can be monitored through the GIS software, both desktop and web.

The potentialities from the web-GIS Smart Atlas available through the CEAMaS platform are as large as we can imagine using spatial approaches to this type of studies. The web-GIS have no intention of replace the desktop software, it could be a perfect combined tool to analyse the DM operations.

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The Dredged Sediments reusability is adapted from work of the CEAMaS partner Dr. Joe Harrington from the Cork Institute of Technology (CIT) and Colm Sheehan (Anthony D Bates Partnership LLP).

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BEES, UCC).

Beyond the seismic data provided by the Geological Survey Ireland (GSI) and the Marine Institute (MI), the data used for every other analysis is freely downloadable from EUROSTAT webpage, believing in the good accuracy of it.

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Marine sediment re-use in the ports of North Western Europe

Toward a spatial decision support system for “Civil Engineering Application for Marine Sediments” (CEAMaS project)

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Abstract— This contribution aims at presenting a spatial decision support system, in a geographical information system and applied to the assessment and the feasibility of a potential reuse path for marine sediments.

Its objective is to compare different ways of adding value to sediment. A geographical information system allows a solution to be spatially analyzed, and was therefore chosen for our study. Then, in a geographical information system, a decision support system was developed and tested. This decision support system is based on a spatial dataset, which considers the places of dredging, the sites of treatment and adding-value, and the sites of reuse. Developments and results, funded by the CEAMaS Interreg IVB North Western Europe project, are presented in this contribution on which to build future analyses.

Keywords— Marine sediments, GIS, Management, Dredging, Decision support system.

I. INTRODUCTION

CEAMaS (Civil Engineering Application for Marine Sediments) is a transnational cooperation promoted through EU funding to encourage knowledge and consensus to raise new solutions of reuse of marine sediments applicable to all of Europe. In Europe, an average of 200 million cubic meters (cu.m) of sediments is dredged every year. The management of dredged sediments is an increasing issue for harbours and local authorities where there is a lack of raw materials for construction at which sediments could be used.

CEAMaS project is a North Western Europe (NWE) Interreg IVB project in which 8 expert partners bring together their contributions, experiences and know-how in order to strengthen the emergence of marine sediments re-use applications. CEAMaS is a European project to promote the beneficial re-use of marine sediments (or valorization) in civil

engineering applications, in a sustainable, economical and socially acceptable manner.

Legislation for handling dredged material is complex and from a policy perspective, dredged material is dealt at the intersection of EU Water, EU Waste and EU Marine Strategy Framework directives. Procedures and contaminant thresholds to authorize dumping at sea, or in land management, considerably vary from one country to another, and no harmonized regulations exist at EU level.

NWE has a long history of marine commercial activity with many ports of primary international importance and huge infrastructure capacities. Many of these ports face serious sediment management issues as a consequence of their position and openness to coastal and estuarine sediment fluxes. In many cases ports act as sediment traps and the cost of sediment management is often a critical factor in respect of the ports economic sustainability. Maintaining advertised safe navigational depth is key to port operations; therefore extensive dredging operations are required and produce increasingly large amounts of material as the ports deepen their fairways and berths to accommodate larger modern vessels.

These factors are driving ports sediment management strategies, which must also take national and European regulations into account. These regulations, which are primarily geared towards protection of coastal and marine environments, apply to many aspects of dredging and govern the fate of sedimentary materials dredged. Such regulatory constraints strongly influence the scope of potential sediment management options, especially for sediments that are less than pristine and may contain varying concentrations of a range of contaminants, which are typically associated with the finer (clay-silt) fractions. In many cases, where sediments fulfill European and National chemical and physical criteria,

the most common beneficial solution is for dumping at sea in specific regulated areas. In other cases dumping at sea is precluded, especially when contaminant concentrations exceed permitted thresholds. In these circumstances, alternatives are required. They typically involve costly storage or remediation solutions.

The overall sediment management cost may however be offset in cases where beneficial re-use options are employed: for instance, through treatments that enable dredged sediment to be converted into an aggregate resource, or, with the potential to replace or supplement materials sourced from the traditional aggregate market. However, because of these additional processings, costs must be taken into account when matching the price of continental aggregates; the economic transport distance for dredged material is reduced. The maximum practical transport distance can be used to define a buffer zone within which beneficial use may be considered as a feasible option. Moreover this buffer area has to be spatially analysed in order to pinpoint the likely areas of interest for each potential reuse application. This issue has highlighted the need of developing a spatial decision support system within CEAMaS project.

Spatial Decision Support System (DSS) are increasingly recognized within the DSS research community [1], [2], [3], [4], [5], because of their broad applicability across a range of fields including, *inter alia*, planning, impact assessment, and environmental management [6], [7], [8], [9], [10], [11], [12], [13]. Specific applications have been developed and combine DSS and Geographical Information System (GIS) to create solutions using weighted sum methodology [2], [3], [10]. The validity and utility of these techniques are now well established in several fields [2], but not yet in the marine sediment management community.

This paper presents an innovative, on going work in a GIS based DSS to provide a range of end-users (port authorities, consultants, regulators, educators...) with customized layers of spatial information covering key aspects, pertinent to the beneficial re-use of marine sediments. This operational decision making tool forms a methodology that integrates a multi-stakeholders decision rule set, processing GIS layers and weighted sum calculations. This methodology is fully detailed in the following part.

II. BUILDING A SPATIAL DECISION SUPPORT SYSTEM UNDER GIS

For this study, a GIS methodology has been defined and adapted to Nord-Pas-de-Calais region of France (Fig. 1), depending on the available data.

This methodology is based on spatial constraints' modeling in a raster mode (Fig. 2), and uses spatial analysis tool to calculate Euclidian distances [14] as a proxy of NIMBY (i.e. Not In My Back-Yard) / BAU (i.e. Business As Usual) qualitative assessment.

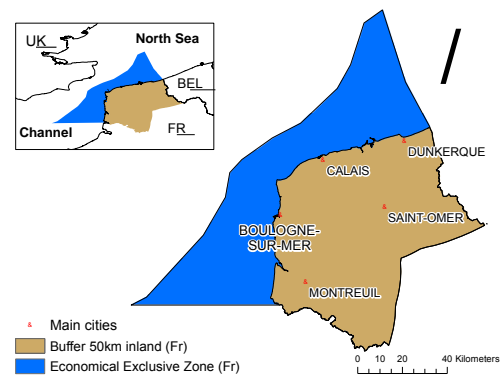


Fig. 1. Location map of the Ceamas French case study (Data source Eurostats 2014, BDTopo® IGN 2012).

A. Raster type-modelling

GIS offer two types of data representation: The vector mode is a discrete objects' model where the information is available only for the existing objects; and the raster mode, which is a grid-like model that corresponds to a normalized spatial sampling following a user-defined spatial resolution [14], [15].

For this project, the choice of a raster-based modeling was dictated by modeling constraints, notably the fact that the elaboration of a spatialised tool to help decision makers follows a multi-criterial assessment based on four types of spatial constraints (attractiveness, repulsion, regulatory and incentive); but also the fact that attributing these constraints to all the geographical objects contained in the GIS data selected must be possible. Here we consider that attractiveness belongs to BAU and repulsion belongs to NIMBY perception's values of any stakeholder.

The procedure chosen is combinatory because the integration of the ensemble of the spatial constraints for each of the GIS data selected is needed in order to produce a spatialised result in GIS.

A vector data's combination induces the problem of the numerous artifacts that are created while crossing multiple data. It is a consequence of the discrete geometry of the vector objects, which do not coincide between layers.

The combination of raster data (Fig. 2), on the contrary, allows the use of a common grid. It offers a rigorous superimposition of the layers and the possibility to realize algebraic treatments of grids on quantitative (all types of calculus), as well as qualitative (mostly for logical computations) data.

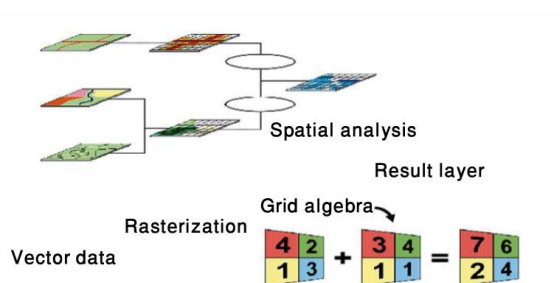


Fig. 2. Raster data treatment's principle (Modified after Zeiler 1999 [15], ESRI 2008 [16]).

Raster data can be obtained by rasterization of vector data. It enables the integration of vector data in raster databases.

The use of raster data predominately permits the mobilization of numerous tools for spatial analysis, especially for the modeling of continuous phenomena in space (for instance the distance considered, in the project, as attractive or repellent).

It was decided to use the Euclidian distance's calculus tool (from ArcGIS spatial analyst tool box, Fig. 3) in order to assess attractiveness and repellence constraints. It is motivated by the fact that this tool allows to model a gradient in a 2D plan, and therefore to measure an increasing, or decreasing phenomenon in space.

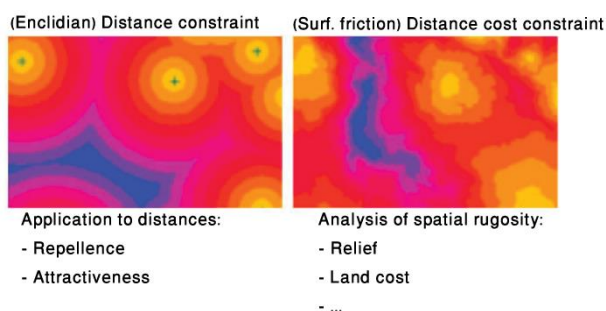


Fig. 3. Spatial constraints principal by use of an Euclidienn distance calcul tool with or without spatial rugosity (Modified after ESRI 2008 [16]).

This device uses a concept that is sufficiently explicit for the assessment model of spatial constraints to be understandable by a wide class of users, decision makers and local communities. It is based on the notion of positive or negative externality, and is close to the hedonic prices' method used in environmental economy [17]: the value of the constraint is a decision cost that allows to accept or decline a spatialised scenario issued from the combination of the four types of constraints available, possibly weighted by the decision maker.

Users can implement this tool rapidly and effortlessly. A large number of location scenarios can thus be quickly produced, and these scenarios can be further refined in an interactive manner by a decision maker.

B. Trading information at regional scale

1) Producing constraints' layer

An attractiveness constraint (Fig. 4) corresponds to an investigation of the proximity in relation to an attractive element in an urban, or regional context. The shorter Euclidian distance to reach the objective is therefore the one offering the least constraint.

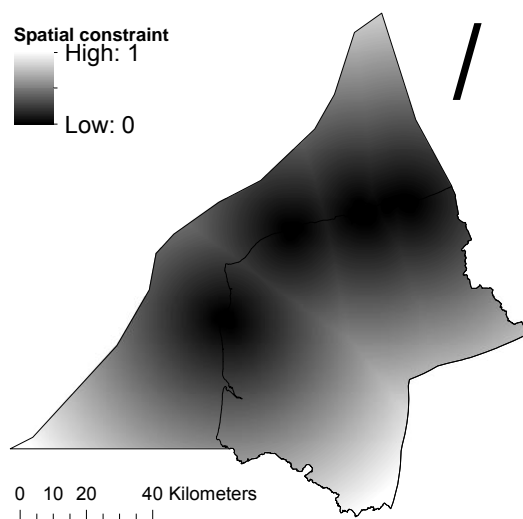


Fig. 4. Attractiveness constraint to ports.

A repellence constraint (Fig. 5) corresponds to an investigation of the remoteness in relation to a repellent element in an urban, or regional context. The shorter Euclidian distance to reach the objective is therefore the one offering the highest constraint. A repellence constraint is decreasing in space whereas an attractive constraint is increasing in space (Fig. 6.)

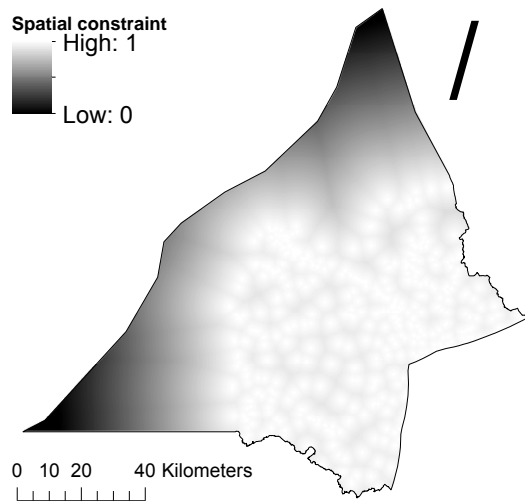


Fig. 5. Repellence – Remoteness to drinking water wells.

In the GIS used, there is no spatial analysis tool to process an inverse distance calculation. In order to obtain this result, a grid algebra tool must be used as follows:

$$\text{InvRastDist} = (\text{RastDist} - \text{DistMax}) \times (-1)$$

Where RastDist = distance raster; InvRastDist = inverse distance raster; DistMax = maximum value of RastDist.

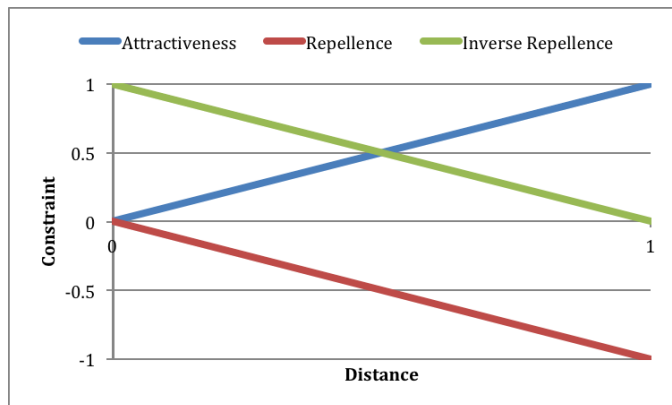


Fig. 6. Spatial propagation of constraints (A) and inverse distance calculation model (B).

To be able to combine the ensemble of the distances, and inverse distance rasters (in other words to combine attractiveness and repellence constraints), a normalization of the distance values is necessary in order for 1) the maximum value to be equal to 1 (the maximum constraint) and 2) the minimum value to be equal to 0 (the minimum constraint).

This data normalization is realized by the maximum value in order to obtain a gradient of constraints spanning from 0

(constraint null) to 1 (maximum constraint) for each raster calculated. For inverse distance raster, the result of the normalization is multiplied by -1 in order to keep positive values varying between 0 and 1.

The normalized distance rasters are expressed as follows:

$$\text{RastDistNorm} = \frac{\text{RastDist}}{\text{DistMax}}$$

and

$$\text{InvRastDistNorm} = \frac{(\text{RastDist} - \text{DistMax})}{\text{DistMax}} \times (-1)$$

Where RastDist is distance raster; RastDistNorm is normalized distance raster; InvRastDistNorm is the normalized inverse distance raster; DistMax is the maximum value of RastDist.

In the cases of both constraints (attractiveness and repellence), the processed data varies between 0 and 1, following rigorously opposed directions. It allows the combination of constraints rasters obtained in coherence with the concepts used. The assessment of the two other constraints (regulatory and incentive) is even easier.

The regulatory constraint is considered as a surface area to be excluded from the final scenario. It is equivalent to a partition of the spatial analysis plan between regulated areas and areas considered as free (from a regulatory point of view). Example can be, at regional scale, the impossibility to build an industrial site in the protected perimeter of a drinking water well.

The incentive constraint is considered as a surface area relevant to an opportunity (development fund, politics, soil use...) to plan the implantation of industrial or storage facilities.

The assessment of these two constraints corresponds to the elaboration of a binary raster (0 or 1). Here again, values are inversed between regulatory and incentive constraints.

For regulatory constraints, all surface areas subject to legal prohibition or recognized as impossible to plan by a territorial agent or a decision maker, have 0 as value. The other surface areas are equal to 1 (Fig. 7).

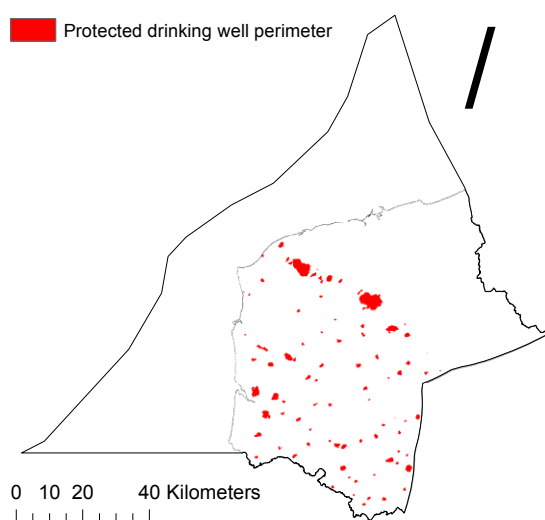


Fig. 7. Regulatory constraint – Drinking water wells' protection perimeter.

For incentive constraints (Fig. 8), all surface areas offering the opportunity of development or recognized as so, have 0 as value when the other surface areas are attributed the value of 1.

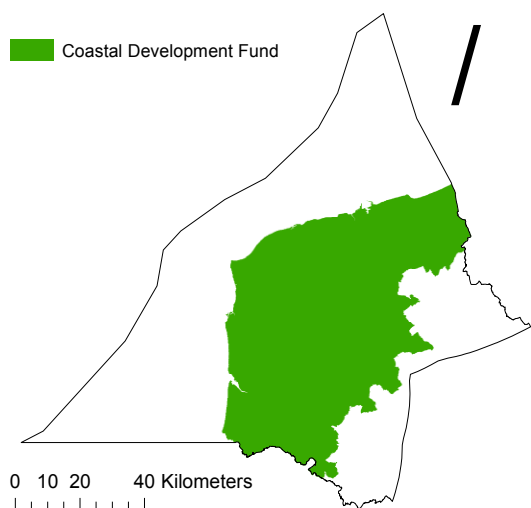


Fig. 8. Incentive constraint – Coastal development fund area.

2) Combining the different constraints by grid's algebra

Four types of spatial constraints formatted as a raster are therefore available for the combinatory analysis by grid algebra. Attractiveness, repulsion and incentive constraints' rasters are integrated by summing, when the regulatory constraints' raster is integrated by multiplying. For a scenario where four constraints are taken into account (thus 4 rasters), the calculus is as follows:

$$\text{RastScenCont} = \frac{(\text{RastAtt} + \text{RastRep} + \text{RastInc})}{3} \times (\text{RastReg})$$

Where RastScenCont is the raster of the scenario of constraints, in other words the result raster of the integration calculus of the four constraints; RastAtt is the attractiveness constraint's raster; RastRep is the repulsion constraint's raster; RastInc is the incentive constraint's raster; RastReg is the regulatory constraint's raster.

3) Creating scenarios by weighting spatial constraints

The direct integration of all the spatial constraints' rasters available can be considered as a reference scenario. However it does not take into account the diversity of the decision makers' points of view or the relative value of a constraint compared to another. In other words, is it more important to be close to main roads or more important to be close to potential deconstruction sites? An informed decision maker would judge that it is meaningful to modulate this relative importance. As a matter of fact, there is no good decision without weighting the decisional criteria, especially when they are numerous. It is also convenient to prioritize and determine the most relevant criteria and their relative importance.

Moreover, the pertinence of a criterion (selection, or non-selection of a spatial constraint), or its relative importance (weights in relation to the ensemble of the criteria retained) depends on the point of view and the expertise of every stakeholder involved in the decision process. Eventually, as shown in **Fejl! Henvisningskilde ikke fundet.**⁹, the injection of certain constraints can have a very significant impact on the decision's scenario (for instance to consider an incentive constraint as equivalent in terms of weight to the other constraints). The system must therefore be open, modular from a catalog of constraints constituting the primary decisional material.

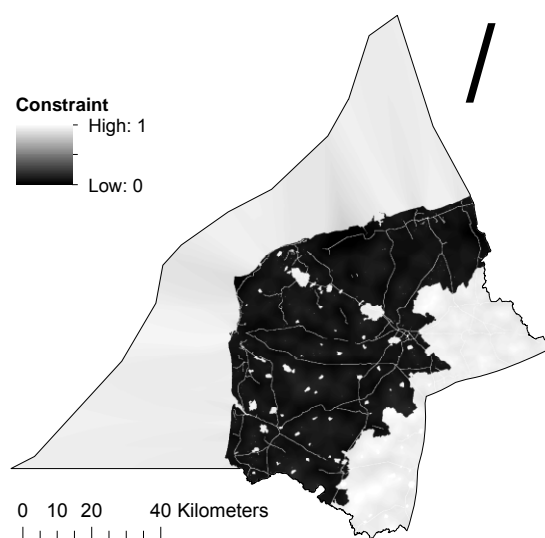


Fig. 9. Scenario using the combination of figures 3, 4, 5, 6 (no weights applied to any constraint).

III. TOWARD FUTURE APPLICATION: NORD-PAS-DE-CALAIS REGION

A. Data set and scenario building

Table 1 accounts for the data used for Ceamas research project in the Nord-Pas-de-Calais-Region. It consists of 44 potential constraints (or parameters) classified in 7 themes, which are land use, coastal areas, natural areas, hydrological, industrial, transports and economical constraints. Different data sources were used to gather this information:

- CORINE land cover (LC), 2009 (from EEA, http://www.eea.europa.eu/data-and-maps/find/global#b_start=0),
- CARMEN, 2015 (<http://carmen.naturefrance.fr>),
- EEA (European Environmental Agency),
- BRGM, 2008 (French Geological Survey),
- AEAP, 2008 (Artois-Picardie Water Agency),
- BD Carthage, 2009 (from the Forest and Geographical Information National Institute (IGN), <http://professionnels.ign.fr/bdcarthage>),
- Eurostat, 2009 (UE - <http://ec.europa.eu/eurostat>),
- BD carto IGN, 2010 (<http://professionnels.ign.fr/bdcarto>),
- SIGALE (Environment Analysis and Geographical Information Systems, <http://sigale.nordpasdecalsais.fr/ACCUEIL/accueil.asp>).

TABLE I. GIS DATA SET USED IN THIS RESEARCH -WITH: PNR: REGIONAL NATURAL PARKS; ZNIEFF: NATURAL ZONES OF ECOLOGICAL, FAUNAL AND FLORAL INTERESTS (1 FOR HOMOGENEOUS SMALL AREAS; 2 FOR HETEROGENEOUS LARGE AREAS); EEZ: EXCLUSIVE ECONOMIC ZONES; ZRR: RURAL REVITALIZING ZONES; FADL: COASTAL DEVELOPMENT'S HELP FUND; ZPAT: PRIORITY ZONES OF TERRITORIAL PLANNING; ZRDP: RURAL ZONES OF PRIORITIZED DEVELOPMENT.

Themes	Constraints (or parameters)	Data sources
Land use	Urban fabric	CORINE LC
	Airports	"
	Dump sites	"
	Artificial non-agricultural / vegetated areas	"
	Arable land	"
	Permanent crops	"
	Pasture	"
	Heterogeneous agricultural areas	"
	Forest	"
	Shrub and herbaceous vegetation	"
	Inland wetlands	"
	Inland waterbodies	"
Coastal areas	Dunes, beaches, sands	CORINE LC
	Salt marshes	"
	Intertidal flatlands	"
	Dumping sea sites	CARMEN
	Coastal erosion	EUROSION EEA
Natural areas	Biotopes' protection	CARMEN
	Nature's hearts	"
	Areas to re-naturalize	"
	Natura 2000	"
	PNR	"
	Ramsar	"
	Natural reserves	"
	Natural inventory (inscribed sites)	"

	Natural inventory (classified sites)	"
	Bird conservation important zones	"
	ZNIEFF 1	"
	ZNIEFF 2	"
Hydrological	Drinking wells	BRGM
	Protected areas	AEAP
	Protected ground water areas	"
	Streams	BD Carthage
Industrial	Ports	Eurostat
	Industrial sites	AEAP
	Active quarries	BRGM
	Geological aggregate use	"
Transports	Waterways	BD carto IGN
	Roads	"
Economical	EEZ	Eurostat
	ZRR	SIGALE
	FADL	"
	ZPAT	"
	ZRDP	"

Building a decision scenario from this GIS dataset consists in selecting appropriate spatial constraints (i.e. parameters) from a stakeholder point of view, applying weight to each selected constraints according to stakeholder's values, computing a scenario by mean of map algebra (i.e. Raster Calculator tool in ArcGIS spatial Analyst® tool box), and displaying the resulting map for validation from the stakeholder.

B. Results and discussion

Two decisional scenarios (Fig. 10 and Fig. 11) have been computed with a selection of various parameters. Scenario 1 (Fig. 10) is a decision case where 6 parameters are selected from the 44 available.

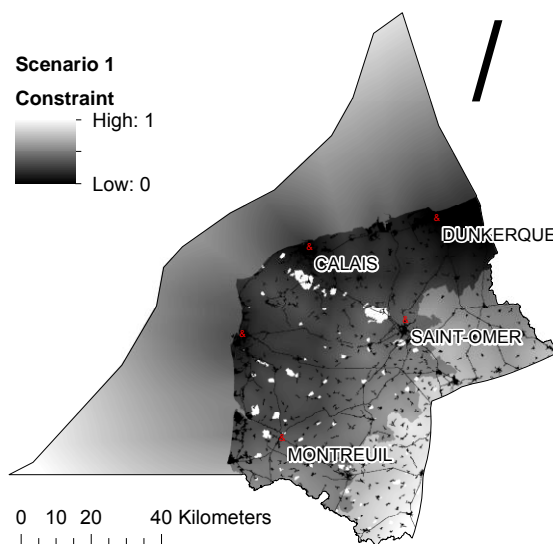


Fig. 10. Scenario 1 – where ports, roads, urban and coastal development fund are positive constraints, with respective weights of 0.3; 0.2; 0.1 and 0.1, and where aggregate quarries are negative constraints, with a weight of 0.3. Drinking wells protection perimeters are excluded from the area of interest (i.e. maximal constraint value of 1).

In this case, the main objective is to locate areas of low constraints where ports sediments can be re-used. Roads, ports and urban locations are attractive whereas quarries are repellent. The coastal development fund (incentive economic parameter) and the drinking wells protection perimeters (regulatory not permitted area) are also included in the decision. Weighted parameters values aim at reducing the transportation costs and increasing the economical competitiveness against quarries.

Scenario 2 (Fig. 11) is a decision case where 8 parameters are selected from the 44 available. In this case, the main objective is to locate areas of low constraints where quarries are associated with the marine sediment resource and where waterways are added to roads for sediment transportation (i.e. all parameters are positive). Quarries locations are included as positive constraint to compute a decision scenario where all aggregate resources are shared to deliver the area of interest. Drinking wells protection perimeters, Ramsar and Natura 2000 sites (i.e. regulatory, not permitted area) are also included in the decision. Weighted parameters values aim at are calculated in the objective of reducing the transportation costs and of increasing the environmental constraint for potential re-use in the area of interest.

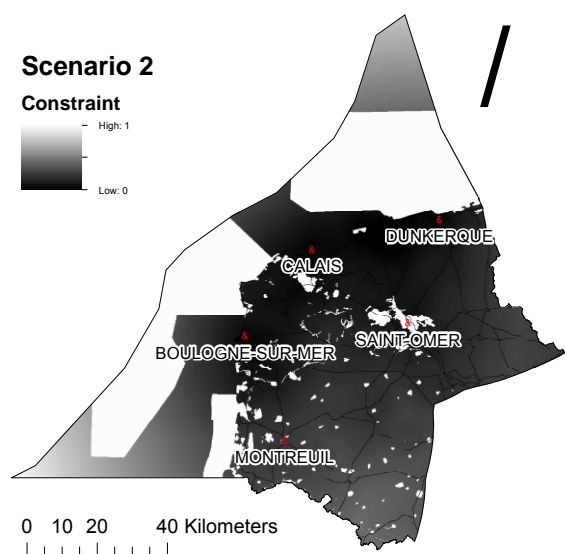


Fig. 11. Scenario 2 – where ports, roads, waterways and quarries are positive constraints, with, respectively, weights of 0.3, 0.2, 0.2 and 0.3. Drinking wells protection perimeters, Ramsar and Natura 2000 sites are excluded from the area of interest (i.e maximal constraint value of 1).

Scenarios 1 and 2 give very different decision maps depending on the number of constraints selected and the applied weights given by “simulated” stakeholders. This spatial DSS is therefore very sensitive and user driven. The final decision has to be built according to a stakeholder process in which each stakeholder has to define his own maximum constraint’s threshold value for scenario validation. Then by spatial combination it is possible to map each validated decision area but also the potential spatial consensus

between stakeholder 1 and 2 decisions according to their own sets of values (Fig. 12).

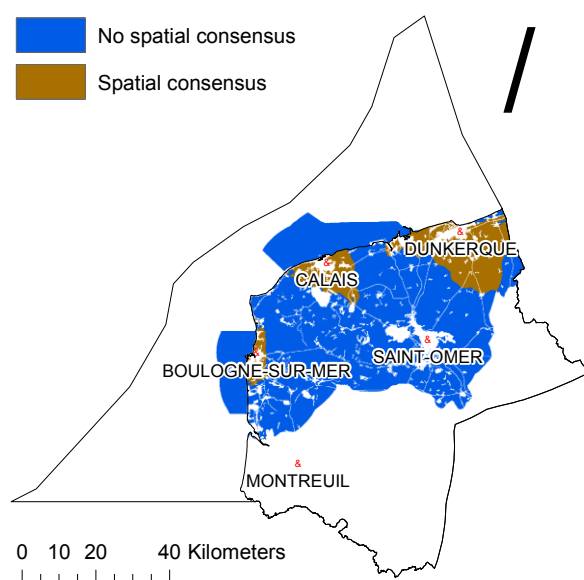


Fig. 12. Spatial consensus. Here the spatial consensus is the result of a combination of both scenarios where a [0-0.2[constraint threshold has been applied for validation in each scenario.

Spatial consensus (Fig. 12) is a strategic area where stakeholders scenarios overlap according to their own decision’s rule set. This common area of interest can then be used for different purposes, including a logistical analysis [18], [19], [20], [21] between potential civil engineering applications or a GIS accessibility analysis [10], [2], [3], [4]. In both cases, the spatial consensus area among stakeholders helps a lot in reducing the amount of potential location to be analyzed. Moreover reducing the threshold value for scenario validation, and/or introducing more stakeholders in the decision process will modify the spatial consensus area of interest accordingly. This spatial DSS is indeed a tool to support the decision process among stakeholders by helping them by:

- sharing a territorial vision between involved stakeholders,
- ensuring that their own decision rules are feeding the DSS and play a role in the final decision,
- mapping the spatial consensus as an area of interest for strategic level’s decision making,
- reducing the need of socio-economical information to select and perform an operational application,
- reducing the number of calculations when using accessibility analysis or logistic models at high geographical scale for operational implementation.

IV. CONCLUSION

The spatial DSS implemented in CEAMaS project aims at being Participative GIS (PGIS) applied to marine sediment re-use in civil engineering application. In this procedure the stakeholder is driving the scenario building and keeps control on every step to reinforce his final trust in the decisional scenario. Moreover each stakeholder can play around with ease in selecting both constraints and weights making this methodology a very flexible tool for project planning at strategic level of decision.

The final aim of this Spatial DSS tool development is to provide the end user with a transparent system from which stakeholders can learn about their own vision of spatial opportunity for marine sediment re-use. This methodology has shown its potential to locate the spatial consensus from which decisional consensus can be discussed among involved stakeholders.

This tool will be tested within CEAMaS project with different stakeholders in Nord-Pas-Calais region France but also in Southern and eastern Ireland at EU Nuts 2 level. A sensitivity analysis will also be undertaken for constraints selection, parameter weighting, scenario's validation and threshold values used to open or close the area of interest in the spatial consensus building process.

This methodology could be potentially used for any spatial location problem involving multi-stakeholders participation and environmental constraints. It can also be used to map individual perception of environmental impacts.

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Methods and Tools for More Efficient Working With OGC Web Processing Services

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Abstract—We start with the observation that the OGC Web Processing Service (WPS) is by far less widespread in public administrations than the OGC download and visualization services WMS, WFS, WCS. Based on this observation, it was the goal of the RichWPS research project to develop methods and tool which should facilitate the use of WPS in practice. Now, after the end of the RichWPS project, we briefly review most of its methodological and technological outcomes and try to conclude to which extent the project goals have been achieved.

Keywords—OGC Web Processing Service, Service-Oriented SDI

I. INTRODUCTION

By the INSPIRE directive, public authorities in Europe are obliged to contribute to the realization of an EU-wide, service-oriented Spatial Data Infrastructure (SDI) for provision and use of geospatial data. It has been shown that OGC Web Services (OWS) provide an excellent basis for realizing such service-oriented SDIs. However, while OGC Web Feature Service (WFS), Web Coverage Service (WCS) and Web Map Service (WMS) are already in wide practical use as download and visualization services, the OGC Web Processing Service (WPS) is by far less widespread in the reality of public administrations.

Although it seems obvious that processing services could (and should?) be the next evolution step of service-based Spatial Data Infrastructures (SDIs) and that distributed geoprocessing has to offer manifold advantages, its usage – since years – is to a large extent limited to academic prototypes. Besides *non-technical* barriers for a wider use of WPS in administrative practice (like the question of “payment” if one administrative unit develops and others re-use a WPS service), at least four *technical* issues related to WPS were identified:

- Composition: simple tools for building complex WPS processes from existing ones
- Retrieval: finding reusable components based on comprehensive semantic metadata
- WPS dialects: data types and encoding of I/O parameters are not equal for all WPS implementations
- Output processing: the data-type agnostic protocol does not tell the client how to further process WPS results

Hence, the aim of the RichWPS research project¹ was to design and prototypically develop methods and tools which support end users (who are no IT experts) in employing WPS for their work.

In the meanwhile, the RichWPS project has been finished, all implementation works have been concluded, and the project results have been validated and evaluated by domain experts from nature conservation and marine-data management. Hence, this paper shall (a) summarize the totality of RichWPS developments and their play-together and (b) draw some conclusions about the usability and usefulness as well as critical success factors and required pre-conditions of the WPS use in public administrations in environmental informatics.

In former publications and talks, (i) the RichWPS overall solution approach, (ii) the RichWPS case studies from environment monitoring and marine-data management, and (iii) the RichWPS orchestration approach and the respective tools for service modeling and orchestration have already been presented (cp. [1], [2]). So, this paper will lay its emphasis on the presentation of the overall solution (Section II) and on the (mostly client-side) components not yet published so far (Section III). Section IV concludes with a summary and short discussion of the project results.

II. OVERVIEW OF RICHWPS COMPONENTS

First, we sketch the overall RichWPS architecture with the main software elements shown in Figure 1 which play together for enabling orchestration of WPS processes by domain experts – instead of IT experts. These main elements are:

The RichWPS **ModelBuilder** (cp. Figure 2) serves as interface for domain experts. It allows graphical modelling of complex processes from existing ones. To this end, the ModelBuilder automatically discovers existing processes and data by using the SemanticProxy. An easy graphical notation is used to build and configure new geospatial workflows. Those can be tested, optimized and finally published and managed using a RichWPS Server. The ModelBuilder itself is not considered a major innovation of RichWPS – indeed, it resembles, of course, very much similar tools from commercial or open source WPS suites. However, the ModelBuilder is the

¹ See also <http://richwps.github.io/>

central point of interaction with the RichWPS system where the knowledge of the SemanticProxy and the functionalities of the RichWPS Monitor can be combined in order to achieve an easy-to-use, yet powerful WPS design-time support.

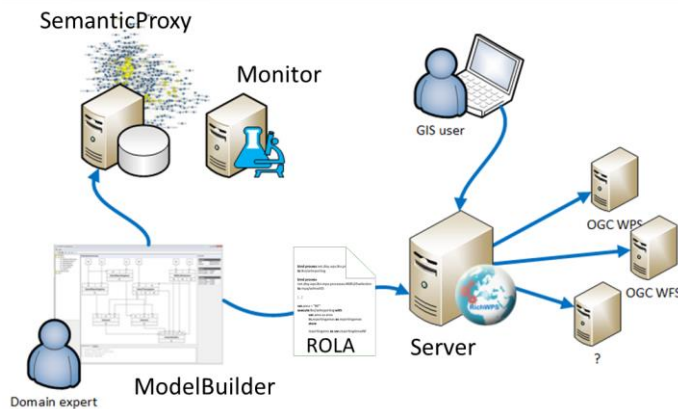


Figure 1: Main Elements of RichWPS Architecture

Figure 2 shows the ModelBuilder with its different parts: the ResourcesView at the left-hand side lists the OGC Web Services (on local machine and in the Web) available for use; the ModelEditor in the middle ground is the canvas for graphical process composition; the StatusView below the ModelEditor gives actual feedback and status information about model and server (error messages etc.); the ButtonBar at the top allows starting different functionalities (testing, profiling, deployment); the PropertyView at the right-hand side

presents characteristics of the resources under consideration (input/output parameters of services, etc.).

The **RichWPS Server** manages the centralized execution of workflows by a custom orchestration engine. Further, it enables domain experts to test, optimize and manage workflows at runtime. Therefore, the RichWPS Orchestration Language (ROLA), a custom language for OWS orchestration, has been developed. The RichWPS **Server** manages the centralized execution of workflows by an orchestration engine that interprets ROLA scripts. The RichWPS server is an extension of the 52°North WPS server with renovated functions for WPS lifecycle management (WPS-T based on [4]). The RichWPS server also allows for testing and optimization of workflows by delivering intermediate results and profiling information to the ModelBuilder at design-time. Further, the RichWPS server provides information about the data types it works with, and it supports the WPS Presentation Directives [3].

Figure 3 illustrates the RichWPS server elements and interfaces. Based on the 52°North implementation, a ROLA interpreter and orchestration engine for local and Web-based services is added, as well as a WPS client API for programmatic access. Besides the standard WPS1.0.0 operations and the operations for WPS-T service-lifecycle management (deploy/ undeploy), the operations TestProcess and ProfileProcess are implemented which allow monitoring of processes during design-time. Further, the operation GetSupportedTypes allows inspecting the server for the input-/output-datatypes supported. Since in our assessment of WPS usage barriers, the incompatibility of different WPS frameworks with respect to IO datatypes was a severe problem

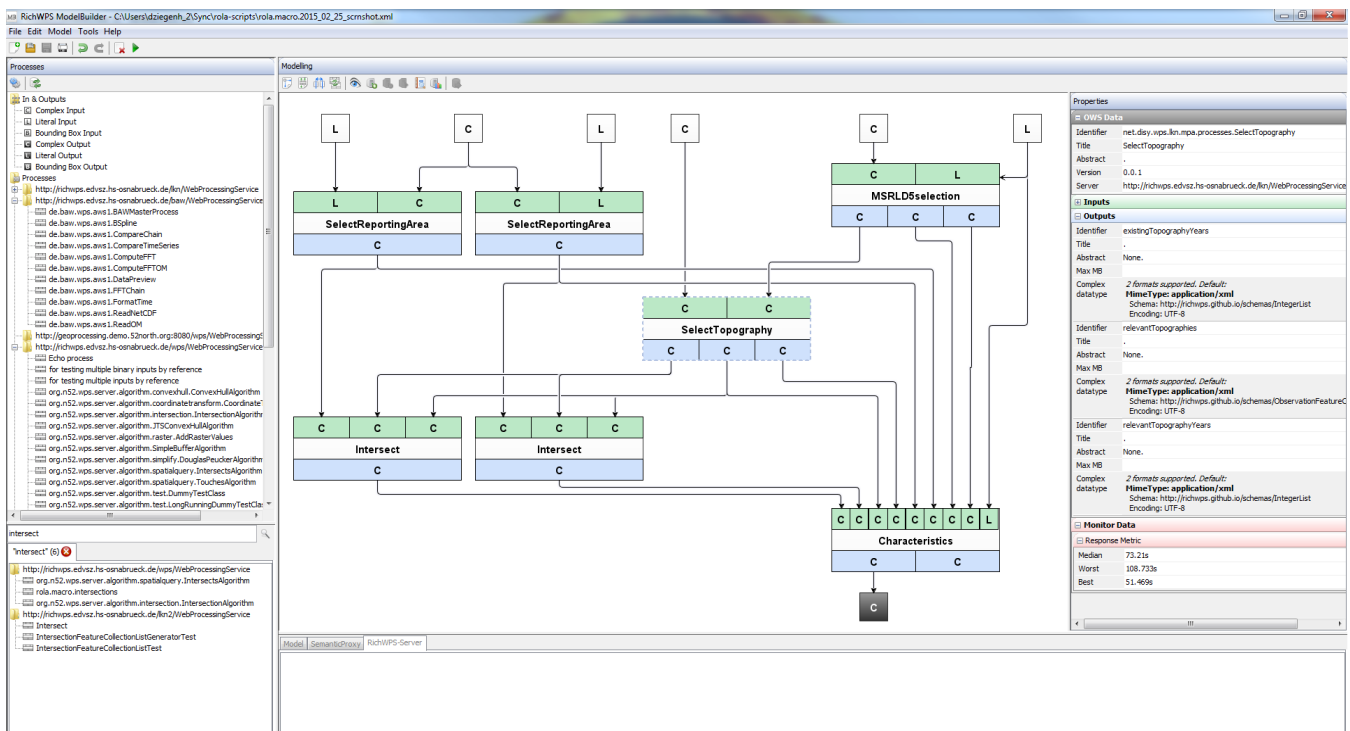


Figure 2: RichWPS ModelBuilder

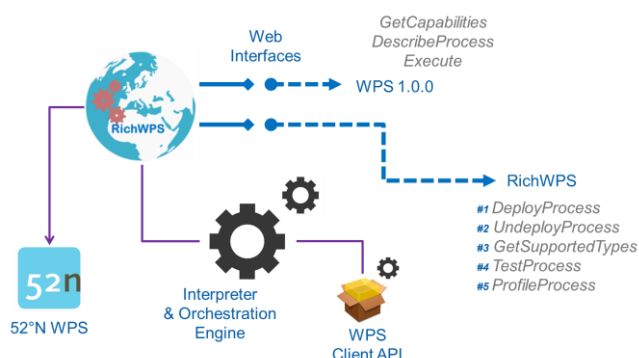


Figure 4: RichWPS Server Interfaces

for true interoperability between servers, we consider this small extension an important thing.

The RichWPS **SemanticProxy** covers the field of OWS service description and discovery. Services (WPS, WFS) can be registered manually or discovered at runtime. The service- and content description takes place using the Resource Description Framework (RDF). Based on that, a custom vocabulary enables the interface- and content-specification beyond OWS service descriptions.

The RichWPS **Monitor** enables the scheduled metering of WPS-services and contained processes. Based on prepared queries the Monitor delivers QoS-information to the Semantic-Proxy. Linked systems, such as the ModelBuilder and the Server, are enabled to optimize workflows when needed.

These components that focus on the upper two issues listed in the introductory section (retrieval, composition), are complemented by client-side extensions dealing with the lower two issues in the list above (WPS dialects, output processing).

III. CLIENT- AND SERVER-SIDE RUNTIME COMPONENTS

A number of further, mostly client-side, developments has been made for facilitating truly interoperable WPS-based infrastructures. Their usage is mostly not necessarily restricted to a purely RichWPS-based environment, but could support any WPS environment. These developments include:

An agent-based intermediate **communication layer for mobile WPS Clients** aims at supporting efficiently dealing with weak or unreliable Internet connections for outdoor work with mobile devices [5]. The idea of this communication layer is illustrated in Figure 4: Two agents establish an intermediate (proxy) layer between stable and potentially unstable parts of the connection and “buffer” network irregularities. The intermediate pair of proxy agents has been prototypically implemented for an iOS and Android mobile WPS client (part of the Cadenza Mobile solution). The agent pair implements a generic and extensible approach able to deal with manifold different optimization mechanisms for different kinds of network irregularities. At the moment, in particular mechanisms for keeping small the network load have been implemented, namely compression algorithms and vector tiling.

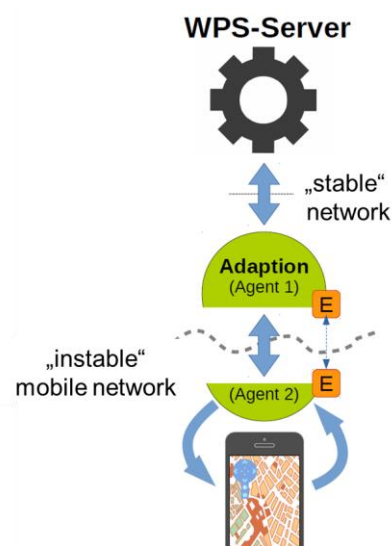


Figure 3: Illustration of RichWPS Communication Layer for Mobile Devices

An **Adapter Layer** for WPS Clients has been implemented that allows working with numerous widespread **data types served by different WPS-server implementations** – including Esri ArcGIS Geoprocessing Services accessed through the ArcGIS REST interface (cp. Figure 5) [6].

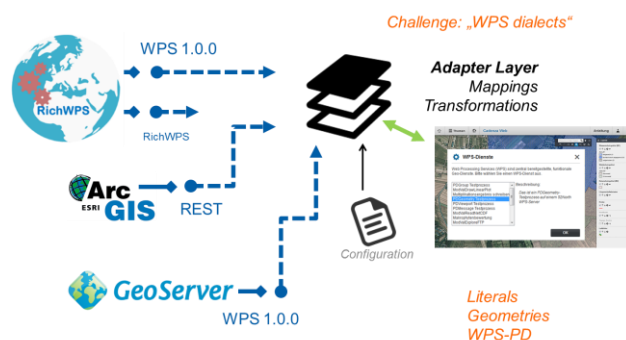


Figure 5: Illustration of Client Adapter Layer for WPS Dialects

This development addresses an issue already mentioned above: Although there is a number of powerful and efficient, commercial and open source WPS frameworks they all differ in details of the input-/output-datatypes they support and how the data are transferred. This is what we call “WPS dialects”. This represents a serious impediment for true interoperability and reuse of WPS processes offered by different server implementations – what we consider a necessary precondition for real WPS-based distributed geoprocessing architectures. Hence we have prototypically developed the adapter layer illustrated in Figure 5: It is a generic and extensible framework where different server and client implementations can be included and the supported datatypes are mapped and transformed in order to achieve interface interoperability. In the prototype, I/O-data from RichWPS, GeoServer and ArcGIS

Geoprocessing have been included at the server-side and the Disy Legato WPS client has been supported at the client side.

A further-development and a prototypical implementation of client- and server-side for the Disy **WPS Presentation Directives** (WPS-PD) [3] has also been integrated. WPS-PD allows the server to communicate to the WPS-client the kind of WPS-result data types and the way how to present them in the GIS. Currently, the following result types are included: Link; Message; Viewport; Marker; Group; StyledFeatureCollection.

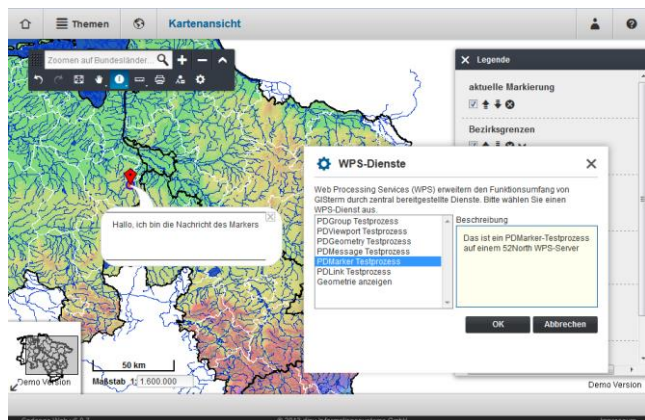


Figure 6: WPS Presentation Directives at the Client-Side

For each of these WPS-output types, the client “knows” how to visualize them. The WPS-PD protocol also makes possible to transmit additional presentation-specific details. Figure 6 shows the simple example of a “Marker” result, transmitted through the WPS-PD protocol and visualized in the Cadenza Web WPS-client as a marker at a specified x-y-coordinate in the map, together with a text message.

IV. RICHWPS PILOT APPLICATIONS

Two pilot installations have been undertaken in the RichWPS project. One of them belongs to the tasks of the implementation of the Marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD) by Schleswig-Holstein's Government-Owned Company for Coastal Protection, National Parks and Ocean Protection (LKN). Together with further North Sea resident countries the status of the North Sea is recorded, evaluated and reported regularly. For reasons of transparency, traceability and comparability this shall be realized using WPS.

The scenario deals with the assessment of macrophytes in the Wadden Sea of Schleswig-Holstein. The spreading of sea weed and algae is a quality factor involved in assessing the eutrophication state for the WFD. The procedure is described in more detail in [7], but in order to provide an impression of the task, the applied data-processing steps are outlined here again:

- Statements are made for a defined reference area.
- Statements about parameters can refer to different, overlapping spaces; they are mapped to each other using a geometrical intersection.

- Statements about spaces are made binary (true/false), quantitatively or gradually – often in relation to the area.
- Exceedances or shortfalls of thresholds mark changes in quality of the environmental status.
- Often multiple factors are incorporated in the calculation. The factors need to be harmonized and mapped to a common scale.
- For the determination of assessment levels a qualitative classification is done.

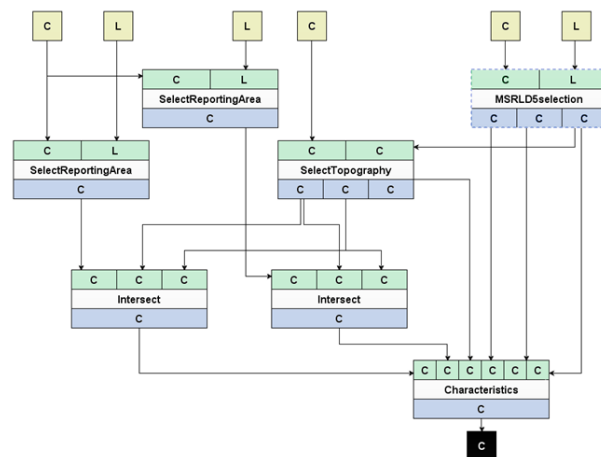


Figure 7: Workflow Diagram for the Macrophyte Assessment Scenario in the RichWPS ModelBuilder

The use case had already been implemented exemplarily as tightly integrated WPS process for the 52°North WPS server [8]. For the test the process is subdivided into several smaller processes that are deployed on a WPS server. Using RichWPS the processes should be recomposed to a workflow. Since new interfaces originated with new data types at the processes, additional parsers and generators had to be implemented.

The resulting processes are:

- SelectReportingArea
- MSRLD5selection
- SelectTopography
- Intersect
- Characteristics

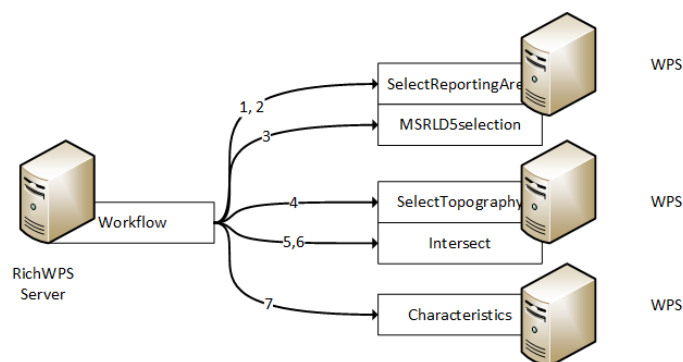


Figure 8: Execution order of Sub-Processes

They are recomposed to an equivalent workflow. SelectReportingArea and Intersect is used multiple times. Figure 7 shows the resulting workflow created with the RichWPS Modelbuilder.

The translation of the model into ROLA creates a sequential workflow script as shown in Figure 8. The workflow is published as a WPS process. Figure 9 shows the result of the example application.

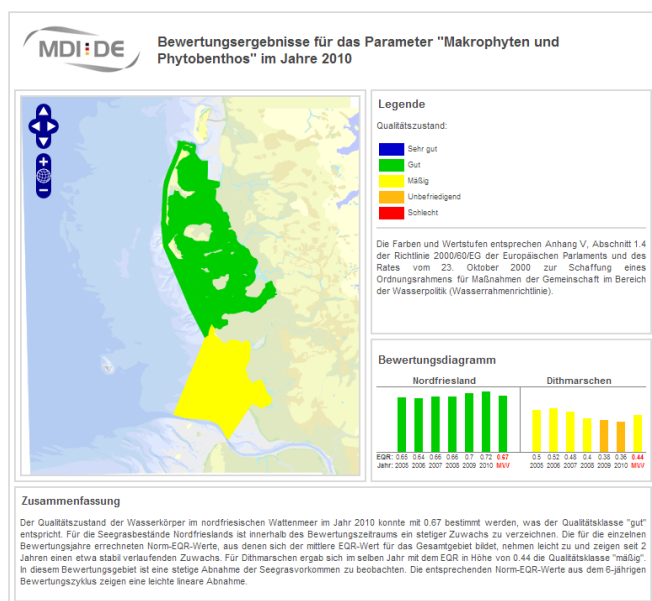


Figure 9: Result of Macrophyte Assessment

V. CONCLUSIONS

The software environment presented has been fully implemented and is partially available as Open Source on GITHUB. Two pilot applications have been realized in the context of the German Federal Waterways Engineering and Research Institute (BAW) and the Schleswig-Holstein Government-Owned Company for Coastal Protection, National Parks and Ocean Protection (LKN). The piloting experience shows that the implemented tools can facilitate the use of WPS significantly. Nevertheless, it was probably too optimistic to expect a solution fully applicable by non-IT people in all respects. Instead, some consulting will probably still be necessary, but more seldom and easier. In particular, the reuse of implementations and the interoperability of independent nodes will be supported.

The RichWPS environment is not "yet another WPS workbench", but extends existing Open Source code (especially the Legato client and the 52°North server, <http://52north.org/communities/geoprocessing/wps/>) by elements not yet provided by other solutions. Parts of the solution could easily be integrated into other WPS implementations. RichWPS addresses the issues identified in the Introduction: (1) ModelBuilder, OrchestrationEngine and ROLA resolve the composition issue; (2) SemanticProxy shows a way how to address the retrieval issue; (3) the client-side AdapterLayer

The work presented in this paper has been developed within the project RichWPS ("Eine Software-Umgebung für Fachanwender zur effizienteren Nutzung von Geodaten mit OGC® Web Processing Services") partially funded by the German Ministry for Education and Research (BMBF) within the SME research programme "KMU-innovativ" under grant no. 01IS12041. The project results have been created collaboratively by employees of Disy GmbH, Osnabrück University of Applied Sciences, the German Federal Waterways Engineering and Research Institute (BAW) and Schleswig-Holstein's Government-Owned Company for Coastal Protection, National Parks and Ocean Protection (LKN).

exemplarily solves part of the WPS dialect problem, in a generic and extensible manner; (4) output processing is facilitated through the WPS presentation Directives.

We do not expect that these contributions are already sufficient to solve "all WPS problems". But we do think that besides the non-technical issues, WPS has significant inherent weaknesses and problems where the approaches presented could provide solution approaches. Based on practical experience, we also consider these problems (especially the interoperability with respect to data types of I/O parameters) severe blockers that *must* be eliminated before WPS can unfold its enormous application potential.

It should also be noted that – according to our knowledge regarding the upcoming WPS2.0 specification – although WPS2.0 will offer a couple of new and interesting features, we do at least not expect that it will address the problems of composition, WPS dialects and output presentation.

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Using system dynamics model to assess aluminium price volatility and propose solutions to save energy

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Abstract – Aluminium production in Vietnam will increase several times over in the next few years if Dak Nong aluminium smelting project is realized. Indeed, aluminium smelting is a commodity industry with highly volatile prices. This research uses system dynamics to predict the industry to explain the part of volatility. Because of huge electricity requirement and potential to reduce electricity consumption through recycling, aluminium smelting is a special interest of environmental research. Besides the large price volatility will impact directly on production and consumption of aluminium and lead to waste or adversely affect to the environment and society. This research begins with initial model of aluminium industry. Concluding with a discussion of system dynamics and commodity production cycles, the focus is on assessing the impact of producers lag time and variable demand to price volatility. The longer the producers lag time is, the larger the price volatility is. Also with variable demand, the price will be larger fluctuated. At the end, by increasing the proportion of recycled aluminium from 25% to 40%, 8.44 Gwh of electricity power will be saved after 96 months and this will open a more sustainable direction for Vietnam aluminium industry.

Keywords—Aluminium, system dynamics model, volatility, demand, consumption, production, price, electricity.

I. INTRODUCTION

A. Overview

Aluminium is an abundant element comprising about 8% of the earth's crust. (The oxide of aluminium is found in nearly all common rocks.). It is the third most abundant element in the earth's crust and the most abundant metallic element. The aluminium industry is the largest non-ferrous metal industry of the world economy [4]. Aluminium is widely used as an input material in several industrial sectors. An estimate of sectoral consumption of aluminium in the principal markets shows that transportation, and building and construction took the largest share [15].

Vietnam has been dependent on imported aluminium to produce about 0.5 million metric tonnes a year worth 23,200 billion VND (1.1 billion USD) [14] with exchange rate fluctuation of 1 USD = ~ 21,000 VND. Vietnam bauxite reserves approximately 2,100 million tonnes and produces about 1.2 million metric tonnes of alumina production a year[14]. This is a point to urge and consolidate the bauxite - alumina - aluminium and complete the connection between the chain of resource industries and the other supporting industries. DakNong aluminium smelting project - the first aluminium smelter in Vietnam - can produce 0.45 million metric tonnes a year 0 and reduce dependence on foreign imports of aluminium. If ingots is 21 million VND/tonne (\$1,000/tonne), annual revenues would be 9,450 billion VND/year (450 million \$/year).

B. Aluminium and Electricity

Aluminium smelting is extremely energy intensive, and it is important to understand the close connection between aluminium production and electricity generations.

DakNong smelter with 0.45 million metric tonnes/year of capacity will consume around 6.3 Gwh/year. Aluminium can be recycled 100% and converted to metal ingots with only around 5% of the electricity required in primary production.

C. Volatility in Aluminium Prices

This figure 1.1 shows the price of aluminium ingots during 1993-2013.

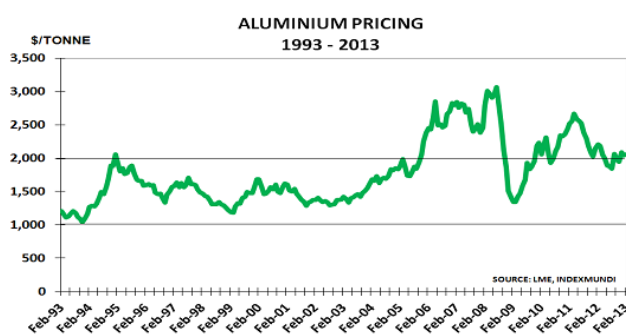


Figure 1.1. Price of aluminium ingots in \$/tonne [9]

The time series shows major swings in the price in a relatively short time interval. For example, within 2009 the price had fallen from 3,000 USD/tonne (63 million VND/tonne) to about 1,500 USD/tonne (31.5 million VND/tonne). Near the end of 1994, for example, the ingot price increased from 1,000 USD/tonne (21 million VND/tonne) to 2,000USD/tonne (42 million VND/tonne).

The large price variations pose difficult problems for the smelter operators as well as their customers. Smelters are complex facilities with a highly trained work force and massive electricity requirements. The smelter owners can't simply turn the smelter on with each upswing in the price or turn them off with each downswing.

To interpret the industry cost curve, imagine that you manage a smelter with a variable cost of 33,000 VND/kg (157 cents/kg). Now suppose the market price for ingots will be remained at 32,000 VND/kg (152 cents/kg). You could operate your smelter and earn 1,000 VND/kg.

But the Figure 1.1 shows that the price of ingots is not inclined to remain constant over time. Rather, we see major price fluctuations by plus-or-minus 100% in just a few years. If you think about your 33,000VND/kg smelter, you will immediately see major opportunities. If your smelter were operating near the end of 2008, you could sell ingots at 63,000 VND/kg (3000\$/tonne), earning around 30,000 VND/kg (143 cents/kg) after covering your variable costs. But what would you do if the price goes under 33,000 VND/kg (158 cents/kg)?

This paper focuses on the underlying causes of the price volatility and its potential to turn the smelting industry into a "roller coaster" industry.

II. STUDY METHODS

A. System Dynamics Model

System Dynamics Model use a graphical user inter face to capture dynamic behavior of the system in a causal loop diagram, also known as a stock and flow diagram. The graphical representation uses a language – a series of symbols and constructs to capture the dynamic behavior of the system.

System can be modeled by understanding the connection between:

External parameters ("smelting capacity") and the system (In this case, aluminium production system)

A system's stocks or quantities which accumulate value ("inventory at smelter and mill")

Flows between stocks or from outside the system ("monthly shipments")

Connections establishing the relationship between stocks and flows

And possibly decisions or thresholds that can cause a system to branch into new states or develop new behavior

Table 2.1. Stock – Funtion



Stock	Function(s)
Reservoir 	Total number of entities – houses the net of what has flowed in, minus what has flowed out. Example: Water, population, cash, inventory.

Table 2.2. Flow – Characteristics

Flow Type	Characteristics
	Standard type, unidirectional indicated by the arrowhead; Uniflow pointing into a stock – fills the stock (and vice versa); If inflow calculated value is negative (flow drains the stock), value is over-ridden by a value of zero – inflows cannot operate as outflows.

B. Initial model

Figure 2.1 shows a diagram for an initial model without consumer reaction to ingot price. One stock is used to keep track of the aluminium will be hold at the smelter and the mill. A second stock represents the aluminium products in use in Vietnam. The model distinguishes between primary production at smelters and secondary production from the recycling of used products. Time is measured in month, and each of the flows is measured in mmt (million metric tonnes)/month.

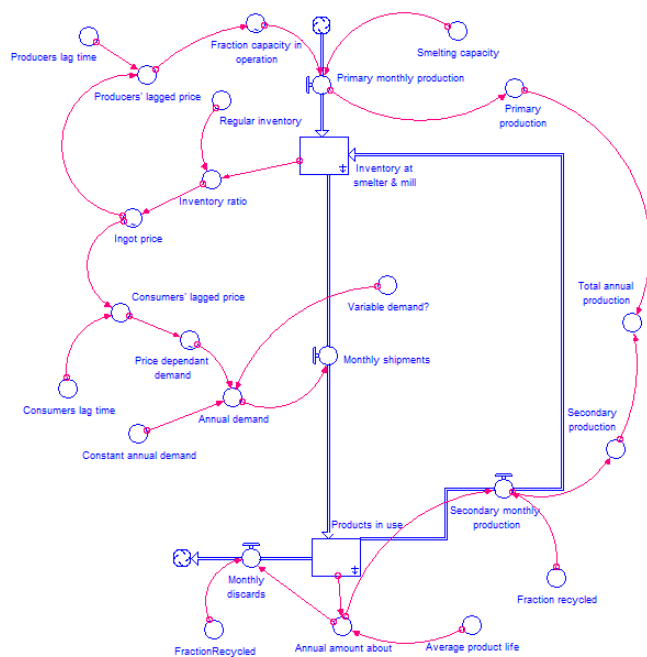


Figure 2.1. Aluminium production and demand model.

Table 2.3. Input data

Regular inventory and inventory at smelter & mill	= 0.09mmt
Products in use	= 5mmt
Fraction recycled	= 0.25
Average product life	= 10 years
Constant annual demand	= 0.5mmt/year
Producers lag time	= 6 months
Consumers lag time	= 24 months
Variable demand?	= 0
Primary monthly production	= Fraction capacity in operation * Smelting capacity /12
Primary production	= Primary monthly production *12
Annual demand	= IF (variable demand?=1) then price dependant demand else constant annual demand
Inventory ratio	= Inventory at smelter and mill/ Regular inventory
Monthly shipments	= Annual demand/12
Total annual production	= Primary production + secondary production

Monthly discards	= (Annual amount about to be discarded - (Annual amount about to be discarded * FractionRecycled))/12
Secondary monthly production	= Annual amount about to be discarded * Fraction recycled /12

“Smelting capacity” is the default refining capacity of DakNong aluminium smelter. “Regular inventory” and “Inventory at smelter & mill” are assumed at 0.09mmt. “Constant annual demand” is the amount of imported aluminium into Vietnam a year. The “?” in “Variable demand?” is a binary variable. Define “0” mean that the price of aluminium does not change demand.

The fraction of smelting capacity that would operate at 70 cents/pound is found by a nonlinear graph shaped to match the industry cost curve in Figure 1.1.

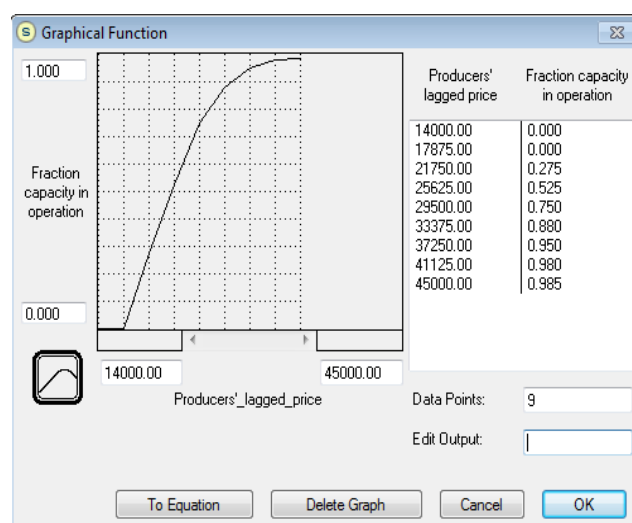


Figure 2.2. Illustrates the relationship between Producers' lagged price and fraction capacity in operation.

The monthly shipments move the aluminium from the mill to the ultimate consumer. The model combines the many uses of aluminium (i.e., automobiles, airplanes housing, beverages, etc.) into a single category with an average product life of 10 years. The total stock of aluminium “products in use” is initialized at 5 mmt. With a ten year product life, approximate 0.5 mmt/year would be ready for discard in the first year. The user specifies the fraction of the potential discards that will be collected and shipped to secondary producers. The “fraction recycled” is set at 25% as defaults to collect scrap rate in Asia based on secondary products (excluding China and Japan)[2]. The recycled products are delivered to secondary producers who extract the aluminium and sell the metal to the mill operators.

The model includes three nonlinear relationships represented by graph functions. For example, figure 2.2 illustrates the relationship between “Producers' lagged price” and “fraction capacity in operation”. The next nonlinear relationship controls the demand for ingots:

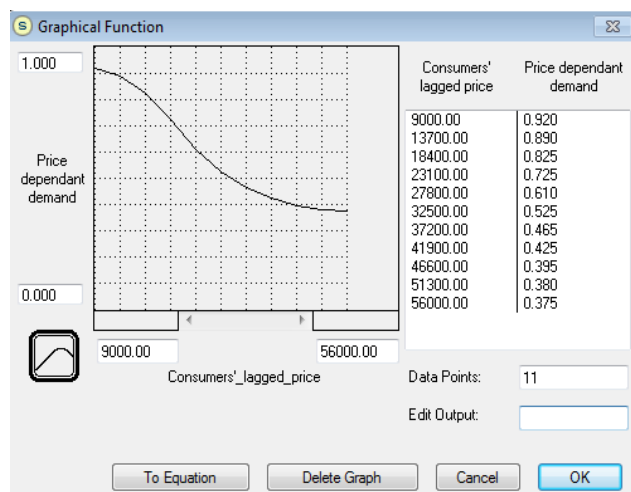


Figure 2.3. Relationship between Consumers' lagged price and Price dependant demand.

The demand for aluminium may change with changes in the consumer's view of price. If the price were to increase from 32,500 to 37,200 VND/kg, for example, this graph would lower the demand from 0.525 down to 0.465 mmt/year. The third graph represents changes in the "ingot price" with changes in the inventory ratio:

A ratio of 1.0 means that the industry has approximately the inventory needed to allow efficient operations of the smelter and the mill. The model assumes that the ingot prices would be at 33,000 VND/kg under these "regular" conditions. Lower values of the inventory ratio are assumed to push the price higher. If the ratio falls to 75%, for example, ingot prices are assumed to increase to 62,750 VND/kg. If inventory fall to 50% of the regular levels, ingot price is assumed to climb even higher to 76,625 VND/kg.

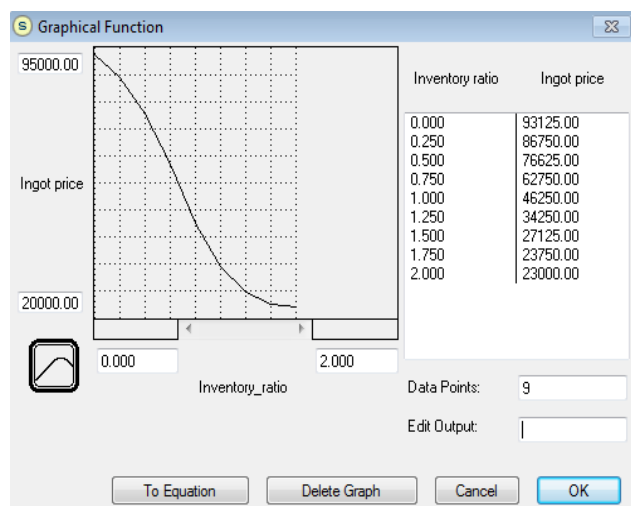


Figure 2.4. Relationship between Inventory ratio and Ingot price.

The model uses two lagged relationships. The first involves the producer's reaction to a change in prices. Assuming that smelter operators watch price changes over a

time interval before committing to opening or closing a smelter. Closing costs could be several million dollars, so we should assume that operators will not react to each and every fluctuation in the ingot price. It makes more sense to assume that they react to a time averaged price which can be represented by a third order smooth function. The length of the lag is uncertain, but let's begin with a value of 6 months.

Producers' lagged price = SMTH3(Ingot_price, Producers_lag_time, 33000)

Producers_lag_time = 6

Consumers are not likely to react instantaneously to price changes either. The initial model assumes that the delay in the consumers' reactions may be described by a third order smoothing delay with a two year lag time:

Consumers' lagged price = SMTH3 (Ingot_price, consumers_lag_time, 33000)

Consumers_lag_time = 24

The third entry in the SMTH3 function is 33,000 for both the producers and the consumers. This means that the simulation begins with both producers and consumers using 33,000 VND/kg as the appropriate price for decision making. The SMTH3 function performs a third-order exponential smooth of input, using an exponential averaging time of averaging time, and an optional initial value initial for the smooth. SMTH3 does this by setting up a cascade of three first-order exponential smooths, each with an averaging time of averaging time/3. SMTH3 returns the value of the final smooth in the cascade.

III. RESULTS

A. Simulating a production cycle

Figure 3.1 shows the simulation results. The "annual demand" for aluminium is held constant at 0.5 mmt/year allows us to concentrate on a situation in which only the producers react to changes in prices. The simulation runs for 96 months to allow sufficient time to see if there are volatile swings in prices. This simulation reveals a production cycle which may be attributed entirely to the operating decisions of the primary producers. "Total demand" and "secondary production" are both constant throughout the simulation. "Primary production" is simulated to decline in the first few months of the simulation because of low ingot prices. The decline in "primary production" causes total production to fall below demand during the first few months. This allows the inventory to decline to more regular levels, and prices are simulated to swing upward. Producers react to the upswing after a delay, and more capacity comes into operation.

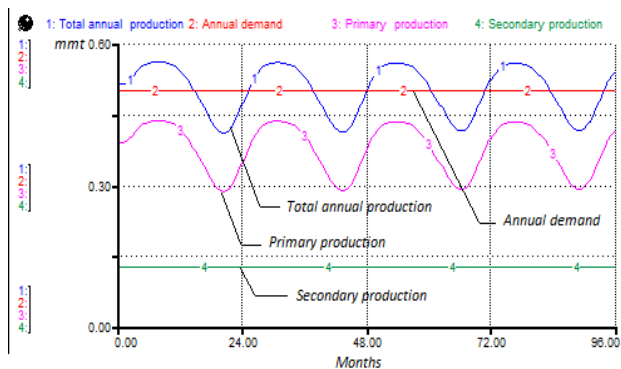


Figure 3.1. Initial simulation of aluminium production and demand.

Figure 3.2 shows that almost all of the smelting capacity would be in operation shortly after the peak in ingot prices. This high production causes inventories to build past the regular levels causing the drop in prices seen around the third year of the simulation. Smelters are gradually taken out of operation during this time period, and the excess inventories are reduced.

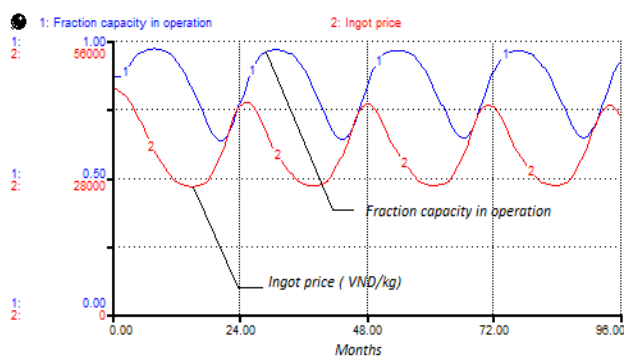


Figure 3.2. Initial simulation of ingot prices and capacity operation.

The simulation reveals that the action of primary aluminium producers could be a major contributor to be volatility in the industry. The simulation shows price swings from a low of around 28,000 VND/kg to the highest of over 56,000 VND/kg. These large swings are quite surprising when you consider that there are no further disturbances after starting out the simulation with extra inventory. Moreover, the price swings occur even though there are no variations in the demand for aluminium, in the amount of secondary production, or in the total smelting capacity.

Figure 3.3 shows the negative feedback loop involving the reaction of primary producers to changes in aluminium price. Primary production adds to the inventory at smelter and mill. This builds the inventory ratio and lowers the ingot price. After a delay to watch and evaluate the price changes, the primary producers reduce the fraction of capacity in operation. This lowers monthly production and allows monthly shipments to lower inventory levels to regular levels. The // on the link from the ingot price to the fraction of capacity operation draws our attention to the key in the loop.

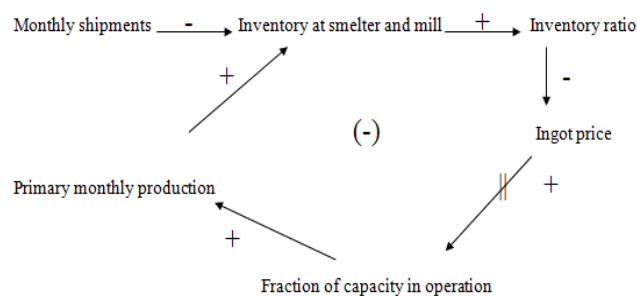


Figure 3.3. Negative feedback responsible for the simulated production cycle.

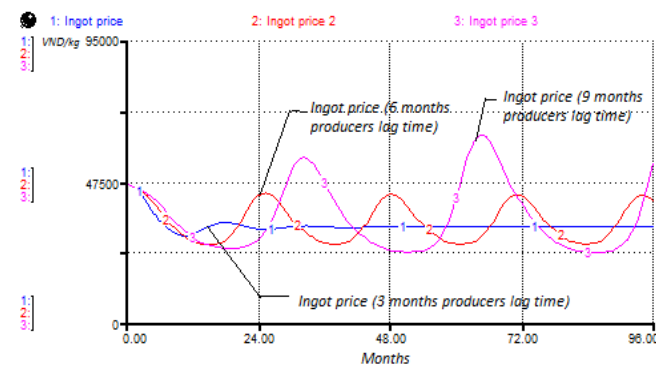


Figure 3.4. Simulated production cycle with three values of the lag in producers' reaction to ingot prices.

Figure 3.4 shows that the longer lag time causes more volatile cycles. It demonstrates that the length of the producers' lag time is an important determinant of the overall stability of the aluminium industry.

B. Adding the Consumer's Reaction

Change Variable_demand? = 1

Figure 3.5 expands the causal diagram to show the reaction of consumers to changes in ingot prices. An increase in price will cause a reduction in consumption and a corresponding reduction in monthly shipments. When less aluminium is shipped, the inventory tends to build more rapidly causing a reduction the price.

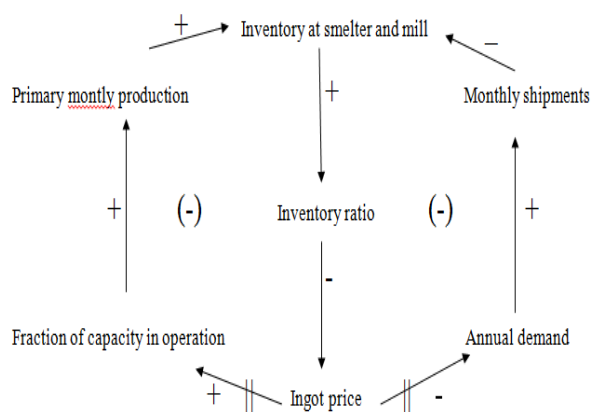


Figure 3.5. Coupled negative feedback loops controlling the supply and demand for aluminium.

Figure 3.6 shows the simulated changes in production and consumption when the consumers' price response is added to the model. The "annual demand" is no longer at the constant 0.5 mmt/year. Instead, we see modest fluctuations in demand as consumers react to the changes in ingot prices. "Total annual production" varies in a cyclical fashion, due to cycles in "primary production".

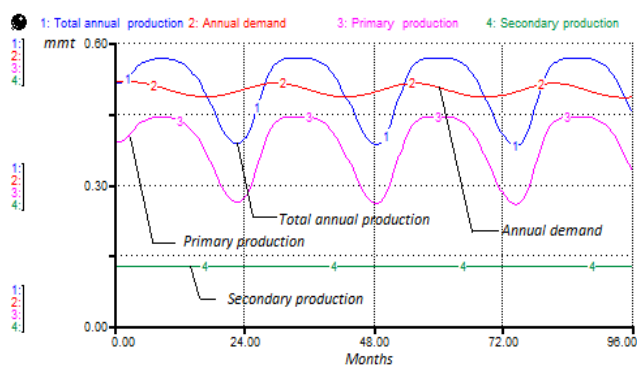


Figure 3.6. Production and demand in a simulation with both producers and consumers reacting to ingot prices.

Figure 3.7 compares the simulated changes in ingot prices in the two simulations. The comparison shows that the introduction response to prices introduces somewhat more volatility to the system. With "variable demand", the cycles show somewhat higher peaks and a somewhat longer period.

The simulation with "variable demand" is the more realistic of the two simulations. It shows cyclical behavior in ingot prices with the cycles taking on the characteristic look of a limit cycle.

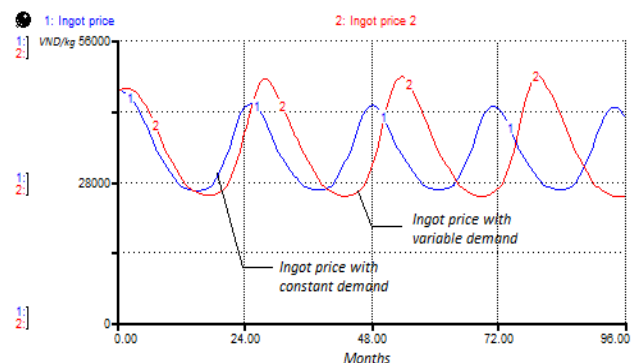


Figure 3.7. Comparison of ingot prices in previous two simulations.

Figure 3.8 displays the same simulation shown in Figure 3.6, but this diagram shows the ingot price versus the "fraction of capacity in operation" from each month of the simulation. The start point is 87% operation and 46,250 VND/kg. The first few months show an increase in the fraction of capacity in operation. By the time the fraction reaches 98%, the ingot price is falling, so dots in figure 3.8 "change course" from a northerly to an westerly direction. The dots then circle down toward 58% and come back around. By the time they have completed one cycle, the system is further removed from the starting point. This outward growing spiral is characteristic of an unstable system.

Unstable systems cannot grow forever; they will eventually encounter limits. In this example, the limits are reached after only one or two cycles. The most visible limit is on the top of figure 3.8. The fraction of capacity in operation cannot exceed 100%. Figure 3.8 also reveals a nonlinear limit on the left side of the diagram. The limitation is somewhat arbitrary. It corresponds to the assumption that aluminium prices are not likely to fall below 20,000 VND/kg even if inventories build to very high levels.

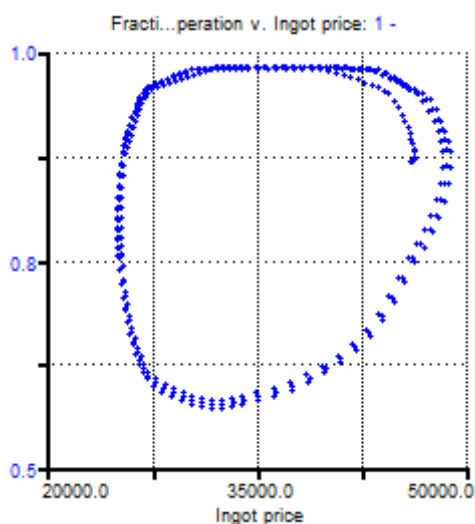


Figure 3.8. Scatter graph depicting the limit cycle in the simulated aluminium industry.

C. Expand model with electricity demand

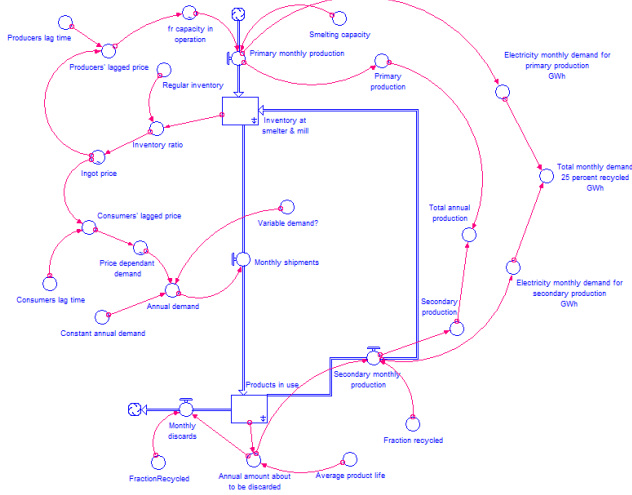


Figure 3.9. Expanded model

This expanded model with power demand in order to calculate the energy savings while increasing Fraction recycled to 40%. Secondary production needs only 5% of electricity required in primary production.

To produce 0.45 mmt aluminium need 6.3 Gwh , which is equivalent to 14 Gwh/mmt0.
 $\text{Electricity_demand_for_primary_production_Gwh} = \text{Primary_production} * 14$

$\text{Electricity_demand_for_secondary_production_Gwh} = \text{Secondary_production} * 14 * 0.05$

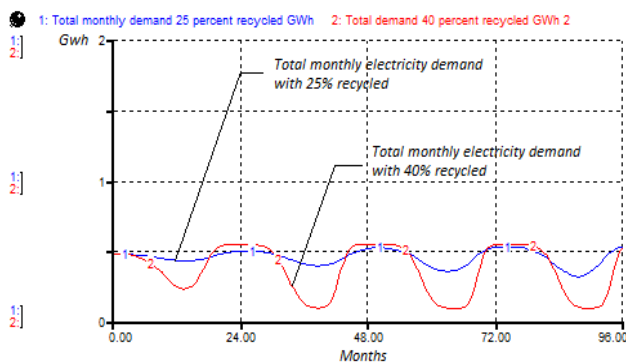


Figure 3.10. Comparison between electricity demand with 25% fraction recycled and 40% fraction recycled.

Table 3.1. Table value of electricity demand with different fraction recycled.

Months	Electricity demand with 25% recycled	Electricity demand with 40% recycled	Months	Electricity demand with 25% recycled	Electricity demand with 40% recycled	Months	Electricity demand with 25% recycled	Electricity demand with 40% recycled	Months	Electricity demand with 25% recycled	Electricity demand with 40% recycled
0	0.47	0.47	21	0.46	0.54	42	0.42	0.23	63	0.35	0.08
1	0.47	0.47	22	0.49	0.54	43	0.44	0.37	64	0.35	0.21
2	0.47	0.47	23	0.49	0.54	44	0.46	0.49	65	0.36	0.08
3	0.47	0.47	24	0.49	0.54	45	0.48	0.53	66	0.38	0.09
4	0.47	0.46	25	0.5	0.54	46	0.49	0.54	67	0.41	0.12
5	0.46	0.44	26	0.49	0.54	47	0.5	0.54	68	0.44	0.22
6	0.46	0.42	27	0.49	0.54	48	0.51	0.54	69	0.46	0.36
7	0.45	0.4	28	0.49	0.53	49	0.52	0.54	70	0.49	0.46
8	0.45	0.37	29	0.48	0.51	50	0.52	0.54	71	0.51	0.53
9	0.44	0.34	30	0.48	0.49	51	0.52	0.54	72	0.52	0.54
10	0.43	0.3	31	0.47	0.44	52	0.51	0.54	73	0.52	0.54
11	0.43	0.28	32	0.45	0.37	53	0.5	0.54	74	0.52	0.54
12	0.43	0.23	33	0.44	0.29	54	0.49	0.53	75	0.52	0.54
13	0.43	0.22	34	0.42	0.21	55	0.48	0.5	76	0.52	0.54
14	0.43	0.23	35	0.41	0.15	56	0.47	0.46	77	0.52	0.54
15	0.43	0.26	36	0.4	0.11	57	0.44	0.38	78	0.51	0.54
16	0.43	0.31	37	0.39	0.1	58	0.42	0.31	79	0.5	0.53
17	0.44	0.38	38	0.39	0.09	59	0.4	0.22	80	0.48	0.52
18	0.45	0.46	39	0.39	0.09	60	0.38	0.16	81	0.47	0.49
19	0.46	0.5	40	0.39	0.1	61	0.36	0.11	82	0.45	0.44
20	0.47	0.53	41	0.4	0.14	62	0.35	0.09	83	0.4	0.37

Figure 3.10 shows the difference in the monthly electricity demand when we change fraction recycled from 25% to 40%. With that change, producers can save around 8.44 Gwh of electricity power after 96 months. If electricity price = ~1,052 VND/kwh (5 cents/kwh)[11], producers can save around 8,900 billion VND (423 million USD) after 96 months, equivalent to over 1,112 billion VND/year (53 million USD / year).

IV. CONCLUSION

Based on scenarios that this system dynamics launched, this research has assessed the role of the lag time of producers and consumers to aluminium market. Since then giving the feedback loops to understand the rules in this industry and limitations of the system.

In next few years, Vietnam's aluminium production will increase from 0 to 0.45 mmt/year if current plans materialize. We need to be prepared for market fluctuations may occur. This research illustrates the use of system dynamics to look "inside a system" for an explanation of highly volatile behavior to predict the future for Vietnam aluminium market. This might help producers understand the system of aluminium production and consumption to make alternative operations suitable for both energy savings and achieve higher economic efficiency. High price fluctuations will affect many aspects of our lives, especially our environment. By increasing rate of secondary aluminium from scrap can help save billions of VND each year from energy use, waste disposal and mining. Thereby, we can see other more sustainable direction in the future instead of the continuous exploitation.

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A process model for preparation and analysis of cetacean sighting data off the coast of La Gomera

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Abstract—

Off the coast of La Gomera sightings of whales and dolphins in the context of tourism whale watching tours are recorded continuously since 1995. The tour operators work together with the German registered association M.E.E.R. e.V., which has set itself the target to evaluate the data scientifically. The aim of this thesis is to develop requirements on a process model for acquisition and analysis of this data material. The recording of the data is performed under difficult environmental conditions in the open sea. The data material should be stored persistently in a database that is accessible to both the employees (full access) and the tourists (limited access) on La Gomera, but on the other hand is also the basis for the scientific evaluation. With appropriate role and rights concepts it shall be prevented, that data is distributed too widely and the animals in the observation area are disturbed. Otherwise the requirements for simple access for all interested parties will be fulfilled. This paper proposes a web-access on the protected database and adds a data export for statistical analysis and a geographically based interface via an adequate layer structure in the GIS ArcMap.

I. SETTING: DOLPHIN AND WHALE WATCHING OFF LA GOMERA AND THE M.E.E.R. e.V.

In many ways, the Canary Islands are hot spots, not only as volcanoes. As for marine diversity of whales and dolphins (cetacean) and the concentration of whale watching tourism, the Canary archipelago ranks in a top position. With 28 out of 85 cetacean species it is home to a diversity that knows no comparison worldwide [1].

The Canary Islands are volcanic islands surrounded by waters up to 3,000 m depth, which favors the presence of some purely pelagic cetacean species (eg, sperm whales, pilot whales and beaked whales) in relative close to the coast. Several species are permanent residents, many more are found regularly over the course of a year.

At the same time, the islands are a magnet for millions of tourists. For example, about half a million tourists alone per year take off from Tenerife for whale watching more than anywhere else in Europe. On the island of La Gomera, however, whale watching is practiced in a sustainable way for many years. M.E.E.R. e.V. contributes significantly to this with its best-practice project MEER La Gomera [2]. Data sets that cover the long periods of time which are for the evaluation, are comparatively rare. The sighting data of the cetacean in the La Gomera area, that are collected by M.E.E.R. e.V. since 1995 represent one of the largest data collections in Europe. The

sighting database of M.E.E.R. e.V. currently holds over 9,000 sightings collected from 1995 to 2014. The data is collected in cooperation with whale watching trips that are offered twice a day. The fact, that the data is continuously for many years practically without interruption collected, makes the database unique in a further aspect: It is not only possible to analyze differences in the occurrence and distribution (for each species) between the years respectively seasonal, but also long-term trends.

The relationship between long-term sighting data and the corresponding environmental parameters could not yet be adequately studied. To enable investigations to this valuable information assets, this article sets the goal to investigate the process from data collection to the representation and analysis and to support it with an integrated software solution in all its phases.

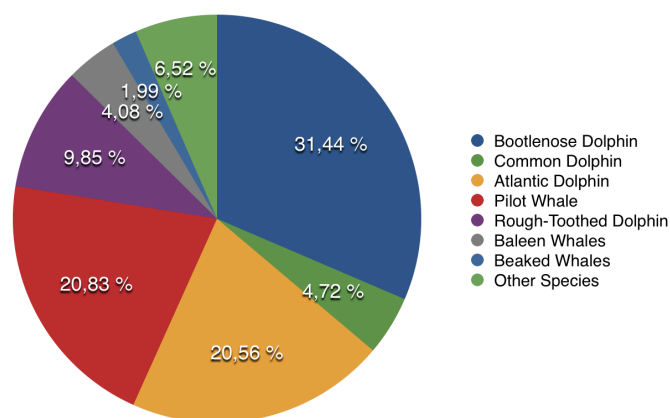


Fig. 1. Relative frequency distribution of cetaceans off La Gomera (1995 - 2007) [1]

II. THE DEVELOPMENT GOALS

In cooperation between the M.E.E.R. e.V. and the university of applied sciences (HTW) in Berlin a project has been set up to develop a state-of-the art data collection, data storage and data evaluation platform with the following basic development goals:

A. Ensure quality of the basic data

The whole project depends on the datasets with daily sighting data, which were collected during the touristy boat

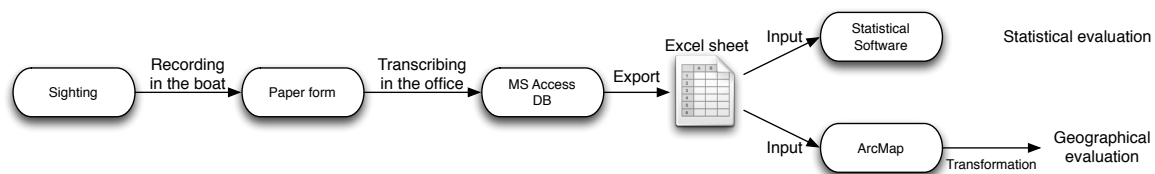


Fig. 2. The current structure of the processing and analysis process

trips. Although the records are just byproducts of the service provided to the tourists, they have to be correct, complete and consistent. Otherwise they would not be useful for analysis.

A view on the data material stored so far on paper-based forms shows with evidence the need of a strict data preprocessing such as

- standardizing names
- consistency check for the position of the sightings
- given possible values for attributes like seastate and interactional patterns etc.
- verification of mutually exclusive details

B. Enable spatial evaluation

In addition to conventional statistical analysis spatial studies are of great interest: for instance the influence of water depth, water temperature, distance to coast etc. as spatial parameters that affect the occurrences of each species. In all cases, the geographical location of sightings plays a decisive role.

If such analysis is intended, it would appropriate to have an interface to a geographic information system (GIS), that provides numberless tools for a spatial data analysis. Also, such studies should be supported. Using a geographic information system (GIS) is perfect for this purpose.

C. Enable statistical evaluation

Based on this basic data set it shall be possible to accomplish statistical evaluations. The data is a comfortable selection of attributes, which are interesting for the analysis. It is necessary to provide a technical interface to the data set for established analysis tools (i.e. MATLAB, SPSS etc.)

D. Use of the data for public relations

To support this research, good public relations are essential. The problems and the research objectives have to be vividly depicted. Otherwise there won't be support ideational and financial by society. The creation of information material which is used for this purpose should be possible by the target system. The focus of this material is the sighting data. This data is processed differently than the processings for scientific purposes. The use of data for public relations is important for advertising for new tour attendees. After all the touristy tours are necessary for continuous observation and collection of data.

The data should demonstrate in the web the continuous work of the M.E.E.R. e.V. on the one hand and should provide the tour organizers and the tourists with reliable data on current sighting possibilities and may be even probabilities on the other hand1.

E. Consideration of privacy issues

The aforementioned aspects are targeted on an easy and comfortable access to the sighting data. Nonetheless it is important to remember that this data deserve protection. Too many tourist boats lead to harassment of the animals. A simple inquest where which animal was sighted recently could lead to similar effects as in the African National Parks. Very interesting sightings resulted in jams of safari vehicles, which have affected the behaviour of the animals significantly. Fishery and hunting interests are opposed to a complete disclosure of data material. This should be considered during designing the system.

III. THE CURRENT STATE

Figure 2 shows an overview of the current structure of the processing and analysis process. The current process begins with the collection of data of each individual observation/sighting on the boat. During the observation a paper form (figure 3) is filled out. This happens for each sighted species. Every paper form is transcribed by hand to an Access-database onshore in La Gomera. On demand the content of the database is manually exported to an Excel-sheet. This file is the starting point for the statistical evaluation with special software applications (SPSS, R, MATLAB etc.).

The problem with this approach is the data consistency. Many different database-versions are in circulation, which are edited and processed in parallel. There is no controlled workflow for synchronisation and update of the database. The Excel-export is used as input for spatial evaluation with ArcMap. In ArcMap the sightings are processed by hand for each version of the data set into thematic maps. The resulting maps allow spatio-temporal analysis by species, season, sea depth, distance to coast etc.

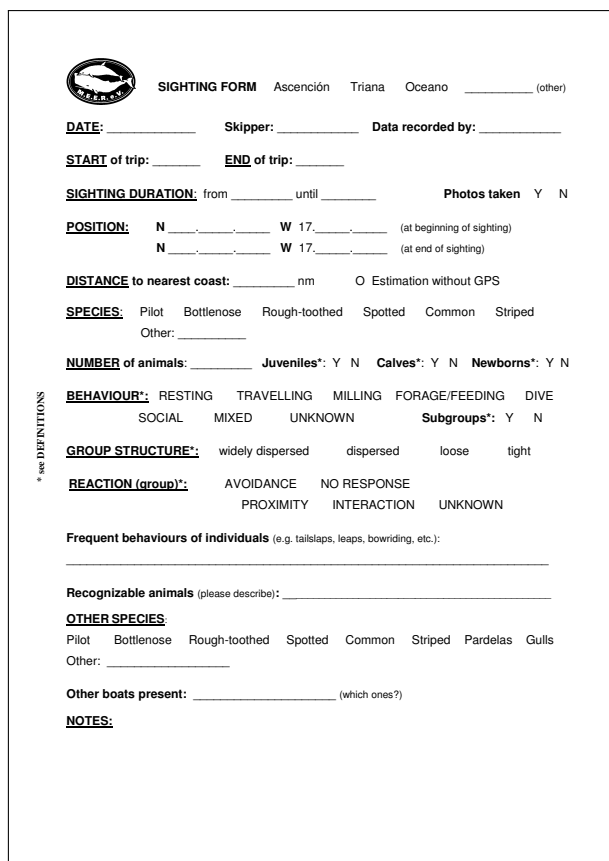
IV. SPECIFICATION OF THE TARGET SYSTEM

As remarked under II the intention of the project was a complete redesign of the data handling process with regard the objectives mentioned and under respect on using adequate software and hardware environment. Thus, the following points will describe the main characteristics of the target system.

A. Replace MS Access/Excel by central database solution

In order to achieve the objectives set out in Chapter II, it is necessary to modify the system described in Chapter III and the currently practiced workflow. Figure 4 provides an overview of the target system's architecture.

The current system's weak spot is the usage of a software solution based on Microsoft Access and Excel. This approach



SIGHTING FORM Ascensión Triana Oceano _____ (other)

DATE: _____ **Skipper:** _____ **Data recorded by:** _____

START of trip: _____ **END** of trip: _____

SIGHTING DURATION: from _____ until _____ **Photos taken** Y N

POSITION: N _____ W 17 _____ (at beginning of sighting)
N _____ W 17 _____ (at end of sighting)

DISTANCE to nearest coast: _____ nm O Estimation without GPS

SPECIES: Pilot Bottlenose Rough-toothed Spotted Common Striped
Other: _____

NUMBER of animals: _____ **Juveniles*:** Y N **Calves*:** Y N **Newborns*:** Y N

BEHAVIOUR*: RESTING TRAVELLING MILLING FORAGE/FEEDING DIVE
SOCIAL MIXED UNKNOWN **Subgroups*:** Y N

GROUP STRUCTURE*: widely dispersed dispersed loose tight

REACTION (group*): AVOIDANCE NO RESPONSE
PROXIMITY INTERACTION UNKNOWN

Frequent behaviours of individuals (e.g. tailslaps, leaps, bowriding, etc.): _____

Recognizable animals (please describe): _____

OTHER SPECIES:
Pilot Bottlenose Rough-toothed Spotted Common Striped Pardelas Gulls
Other: _____

Other boats present: _____ (which ones?)

NOTES:

Fig. 3. Sighting paper form

has its strengths in a local office environment. However a local use no longer meets the requirements. The database has to be writeable and retrievable from different locations. With MS Access this is not easily achievable. It is necessary to use a relational database management system on a centralized server. This allows consistent versioning of the database, which was not possible with the previous system and procedures.

The data structure represented in the Access database is a grown system which does not satisfy current standards of data modelling. Redundancies and anomalies can be prevented by a remodelling and normalization of the existing database design. Data is summarized and arranged in a more reasonable way (figure 5). This ensures consistency of the stored data, which is important for data security and continuity without data loss during creation of new entries and modifications of existing ones.

The database on the server is the heart of the new system. In addition to the database, there is a server-side backend. This backend makes it possible to implement an API (Application Programming Interface), which can be addressed by different client systems (web, mobile etc.). This API allows data input by different clients as well as output of the data via web interface plus the export into an Excel file. Data security has a very high priority. Current standards of authentication guarantee, that only authorized clients have access to the backend and consequently the database. Data will be transferred encrypted only.

By replacing the current solution by a web-based application, it is possible that multiple users can work with the database with the same state of data at the same time. In addition, the new solution is usable platform independent. To use the new system, just a computer with internet access and a modern internet browser are necessary. Therefore the usage does not require a computer with an operating system from the Microsoft Windows family. It is also runnable on devices with operating systems such as Linux or Apple Mac OS X. Also, since the entire data can always be accessed in an up-to-date state via internet, the user does not rely on a specific computer.

B. Optimize Excel Interface

The system architecture provides that sighting data will be kept in a central database. In addition, it must still be possible to proceed statistical and spatial-temporal evaluation in specialized software systems like SPSS or ArcMap.

The new architecture still uses an Excel-Interface as exchange format. It turned out that importing this format into the specialized software is quite easy. Furthermore, it is a transparent and human readable form of data transfer. For statistical evaluation the entire dataset will be exported into a single table. This simplifies the import into the statistical applications.

For spatial evaluation in GIS the table will be preprocessed during export. Data will be combined into several sheets, so it won't be necessary to use additional selection methods to transfer the data into previously generated layer structures. Thus the data access will be still pretty easy, though it creates several new versions of unsynchronized and unmaintained dataset. This approach is pragmatic and reasonable, because the basic data isn't modified, but just read. This regards both, working in GIS and statistical analysis.

In addition, the concept supports an update to the latest version of the data set by a semi-automatic export-import mechanism via the Excel-file interface. Editing of the basic data should be allowed only via the database interface.

C. Web output

There are three layers on which the web output of the data shall be possible:

- 1) Easy and comfortable database access for project staff:
So far, the system comes with an Access view and further processing in Excel. With the new system, it shall be possible for project staff to maintain a comfortable view (figure 8) and the possibility of subsequent data processing in the browser.
Due to the order records are stored in the database, it will be possible to visualize them in a fast and simple manner, whether as a report, graph or table.
- 2) For tourists:
The data set makes it possible to provide special processed data and information about their tour, so the tourists can experience the tour again and have additional benefit and a nice souvenir of their trip. For this view critical information will be hidden.

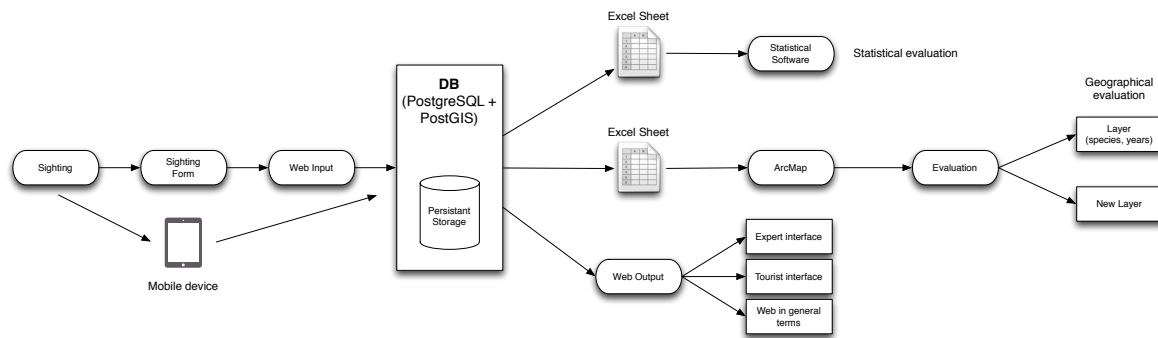


Fig. 4. The processing and analysis process in the target system

Another use of the sighting data would be a forecast of future sightings. Prior to booking of a whale watching boat trip, tourists could get information, which sightings might be possible under current conditions.

3) For general info site:

With the API, it is easy to make sighting data accessible in processed form on the website of M.E.E.R. e.V.

D. Optimize data entry

An input mask in the browser replaces the input form in MS Access. Via mobile devices, such as smartphones and tablets, it is possible to enter sighting data into the database digitally and directly.

This renders filling out sighting paper forms and their subsequent transfer to the database unnecessary. Thus, a media break, which is not only labor intensive but also error prone, can be avoided. By managing the data input in direct connection to the database in behind all restrictions, rules, and interdependencies between the data entries can be controlled online and the typical transcription errors due to illegible handwriting or typing errors, can be reduced and the consistency and the completeness of data can be enhanced significantly. The result is a notably improved quality of data.

E. Provide GIS structures for analysis

Recurring steps can be identified for data processing and analysis in GIS:

- a) Import of the data table (database connection)
- b) Adjustment of the geographical coordinates of the data format used in GIS
- c) Processing of the data set into individual standard layer with sightings by species, observation period, location etc. including pleasant symbologies.
- d) Determination of the sea depth for the positions of sightings
- e) Determination of the distance to the coast for the positions of sightings
- f) Providing spatiotemporal maps for other environmental parameters such as surface temperature of the sea, chlorophyll level, etc.

The latter point is solved through a suitable research and the integration of the corresponding thematic maps in the GIS.

The items a) to e) represent steps, that

- 1) concern the import of existing data (step a) to c)). After the basic structures are created in the GIS, step a) to c) can be automatically executed by an update tool.
- 2) complement existing information about spatial attributes (step d) and e)). This feature should be triggered under user control.

The Python scripting interface of ArcMap [3] is perfect for both types of actions. A more user-friendly alternative would be an additional visualization by so called Modelers [4].

As Jermann demonstrate in [5] most of these steps can be executed automatically and produce maps with sighting visualizations even on a daily basis "just at the touch of a button".

V. THE ACHIEVED SUBGOALS

A. Processing of the data material

First of all, for preparation numerous Excel sheets in circulation had to be collected and merged. This work was performed manually. The present database contains more than 9,000 data sets of sightings continuously from the year 1995 to March 2014.

In addition, based on nautical maps, the Access database was completed by adding the missing attributes sea depth and distance to coast. The correctness of the data was checked using the sighting paper forms (figure 3) and corrected if necessary. This provides a complete and consistent data basis for the integration of the new system architecture.

B. Implementation of the central database component

To implement the web application the programming language Ruby and the Ruby on Rails web framework has been used. Ruby on Rails is considered a very safe and stable framework that is being actively developed and maintained. It innately comes with many features required in the target system.

As database management system, PostgreSQL with PostGIS is used. PostGIS is ideal for storing spatial data like sighting positions and their distance to coast.

The API is based on the REST (Representational State Transfer) paradigm by Roy Thomas Fielding [6] and uses JSON (JavaScript Object Notation) [7] as exchange format.

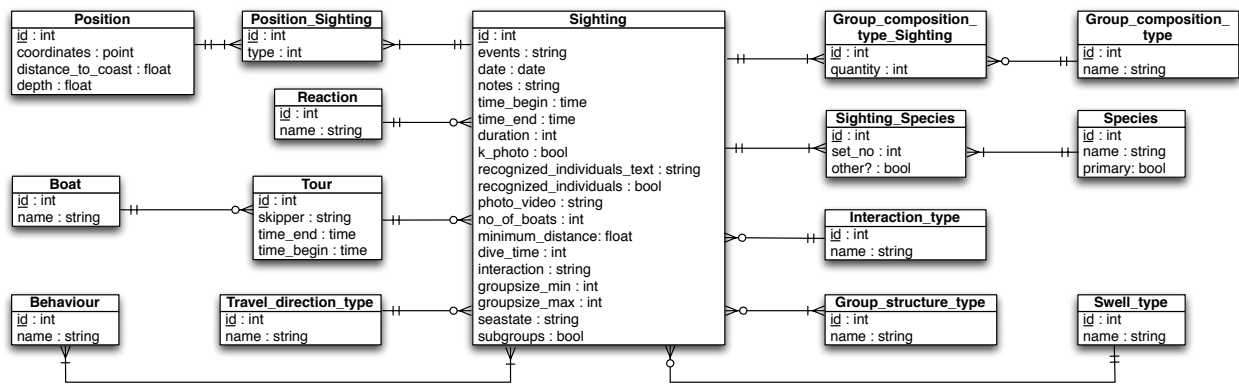


Fig. 5. ER model of the target system's backend

Because of the usage of HTTPS, the data transfer is generally encrypted. The view layer of the webapplication is implemented with a mixture of Twitter Bootstrap and the JavaScript HTML5 framework Ember.js.

For the mobile application view Sencha Touch is used. With a framework like Sencha Touch based on modern web technologies, it is possible to create a platform independent offline-enabled mobile application without using platform-specific APIs [8]. To get a native/hybrid mobile application, the mobile web view is wrapped in a PhoneGap container [9].

All technologies used are Open Source and are free of licence fees, which meets the limited budget of a non-profit project.

C. Composition of data structures within the GIS

The data structures outlined in Chapter IV-E are created in ArcMap. They already allow visualization of the first reports as sighting maps which can be generated according to the attributes that are interesting for the evaluation.

For example (all figures from [10]):

- map of sea depths of all sightings (figure 6)
- map of sightings by species in April 1995-2011 (figure 7)
- map of sightings of one species (Bryde's whale) in september for all observed years (figure 9).

Based on this map material, it is now possible to analyse the data under several aspects like correlations between the occurrence of the species among themselves, neighborhoods, observation period, sea depth, inshore and the additional parameters which are mentioned in Chapter IV-E. The (geographical) sighting position and the temporal dimension via sorting by year are visualizable and allow an extended view of the base data that outreach a purely statistical analysis.

VI. FUTURE PROSPECT

In the steps described here, a software environment could be created that allows domain experts to proceed spatial and time-related analyzes on the valuable record of the cetacean sightings. The consistency of the data management is ensured by the central database server solution. The different user profiles are represented by a corresponding role concept. The implementation of a web-based solution provides comfort

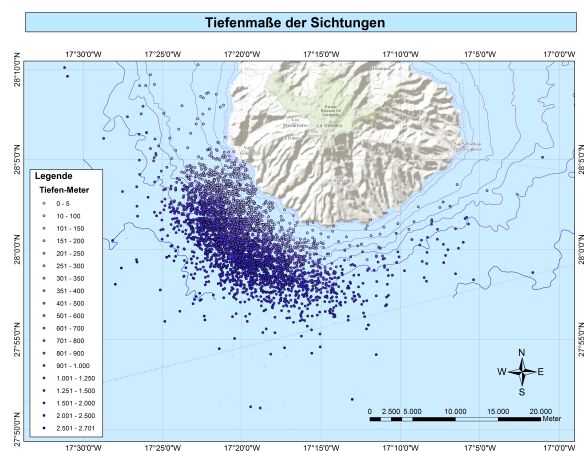


Fig. 6. Sea depth at the sighting positions (from [10])

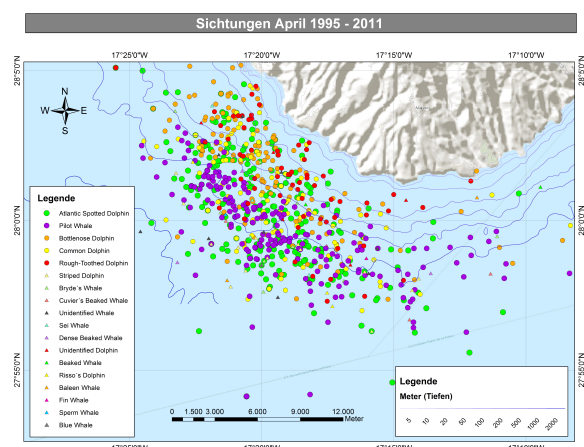


Fig. 7. All sightings in April by species (from [10])

M.E.E.R. e.V.

Sighting Details (# 9357)

All Sightings

Tour	
Skipper	Carmen
Tourdate	04.03.2014
Boat	Ascension

Sighting	
From	11:15
Duration (HH:MM)	00:50
Species	Bottlenose Dolphin
Start-Position	28.00.58 N
End-Position	17.19.41 W
Distance to coast	3,5 km
Sea Depth	600 m
Sea State	
Group Size	40
Group Structure	Dispersed
Juveniles	Yes
Calves	Yes
Newborns	No
Subgroups	Yes
Behaviour	Travel
Reaction	No Response
Other species?	No
No of boats	1

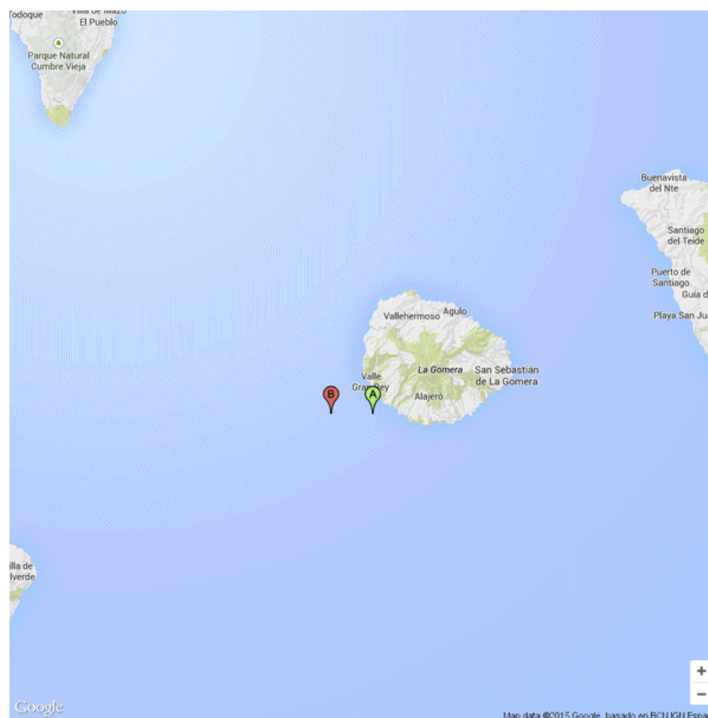


Fig. 8. Screenshot of sighting details in the web application

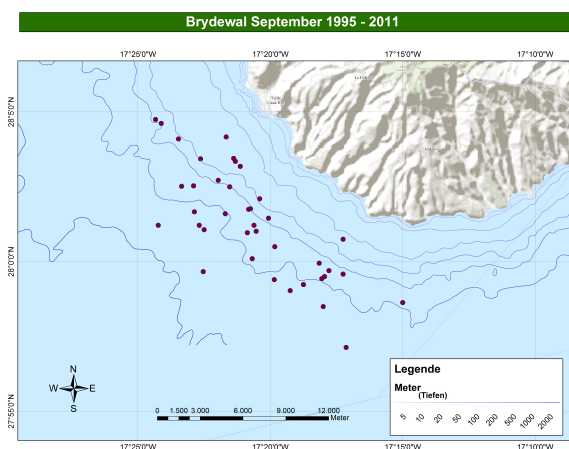


Fig. 9. All Bryde's whale sightings in the month of September (from [10])

using the latest software components. The GIS connection simplifies data transfer for spatial analysis.

The next steps are now the actual investigation of correlations between observational data and environmental parameters. Here the GIS provides powerful tools. First considerations suggest that the analyzing workflow will be a mixture of conventional statistical methods and GIS tools. This leads to further considerations and concepts allowing an intuitive problem-oriented operation and spatial-temporal evaluations.

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Development of a Real-Time Smart Meter for Non-Intrusive Load Monitoring and Appliance Disaggregation

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Abstract—Current studies about electrical energy efficiency potentials bring out that to make the most part of the saving potentials achievable, a feedback about the instantaneous consumed electrical energy is necessary. More detailed, an allocation of the electrical load to the particular device can enable a greater level of sensitivity in energy consumption of electrical appliances. Therefore, we pursued the aim of developing a low cost smart meter hardware, which fits the requirements for the detection of several devices and states via disaggregation algorithms. This is implemented by applying Fast Fourier Transformation to the measured data and sending the Fourier coefficients to the appliance disaggregation modul. In this paper, we describe the developed hardware in detail and show a visualization approach of the disaggregation results for providing the user with detailed information about device states.

I. INTRODUCTION

Today, the energy turnaround from fossil to regenerative energy exposes monitoring of energy demand and exhausting of energy saving potentials as major factors for its realization. Armel et al. [1] analyzed research results of energy saving potentials in residential buildings, where they pointed out that 20% energy savings are achievable overall. It is observable that the kind of energy consumption feedback is of high importance for the execution of the energy saving potentials. Feedback about energy consumption provided after the consumption occurred, like analyzing bills, at most makes only 4% energy savings achievable. In comparison, real time feedback in combination with allocation of the consumption to single devices (disaggregation of the sum signal) can reach up to 12% energy savings [1].

Therefore, modern measurement instruments are able to transfer measured data directly into the cloud for providing feedback about the power consumption. A cost efficient approach is to use a smart meter installed at a central point and to perform load disaggregation (non-intrusive load monitoring, NIALM). Commercially available smart meters are designed to calculate power consumption precisely and transfer active and reactive power with a limited resolution of one minute up to one second intervals between measurements. When using this data as feature for disaggregation, the number of detectable devices is relatively low. Large appliances can be disaggregated, like refrigerators, heaters and washing machines (about 10 appliance types [1]). To distinguish between devices of similar power consumption, their current signal shape can be

analyzed, which is influenced by harmonics (integer multiples of the fundamental frequency). These harmonics, which are produced by electronic components because of a nonlinear current-voltage behavior, can be calculated by applying Fast Fourier Transform (FFT) to the measured signal. Using harmonics as features for disaggregation algorithms considerably increases the number of detectable appliance types (up to 40 appliance types [1]). Hence, a high sampling rate (in kHz range) for FFT calculation and a fast processor for real-time signal processing are necessary.

Because the market lacks those smart meters, we developed a smart meter for our application case, which is described in chapter III. Thereafter, we focus on our prototypic visualization system in chapter IV.

II. RELATED WORK

There are two options for metering hardware: first, to use and possibly upgrade existing smart meters for appliance disaggregation purpose and second, to use smart meters developed especially for appliance disaggregation. In market studies, research projects analyzed available smart meter systems [1], [3], [4], whose installation is proposed by many utilities to provide higher resolution electricity data. They come to the result that transmitting raw load profiles, sampled at frequencies in kHz range, which makes a firmware upgrade necessary, is the bottleneck. A possible solution therefore is the recommendation for future smart meter development to improve data compression, to implement a transmission of events and to equip the smart meter with wi-fi [1].

As mentioned before, with the use of harmonics the amount of detectable appliance types increases a lot, which is explained e.g. in this review paper [2]. In our present research [12], we analyzed that harmonics up to 2,000 Hz in the signal contain significant amplitudes, which are above the magnitude of noise. This corresponds to 41 Fourier coefficients, we used for the disaggregation algorithms and represents a much lower amount of data to describe the measurement signal detailed (cf. chapter III). So we decided to choose the second way of a purpose-built smart meter for appliance disaggregation, which went several other research projects as well [5]. During the project period, also two purpose-built smart meters were released to the market: Smappee [6] 2014 and Neurio [7] 2015. Both measure the current via current transformer and voltage transformer and transfer the data via wi-fi to the cloud.

In our project we focussed on using standard hardware components and being able to select and fit the sent data to the needs of our developed algorithms.

III. DEVELOPED SMART-METER

The application case of load disaggregation caused an own development for the smart meter, which is treated in this chapter and depicted in figure 1. First, the determining requirements were gathered, which are followed by the description of the metering board and the firmware.

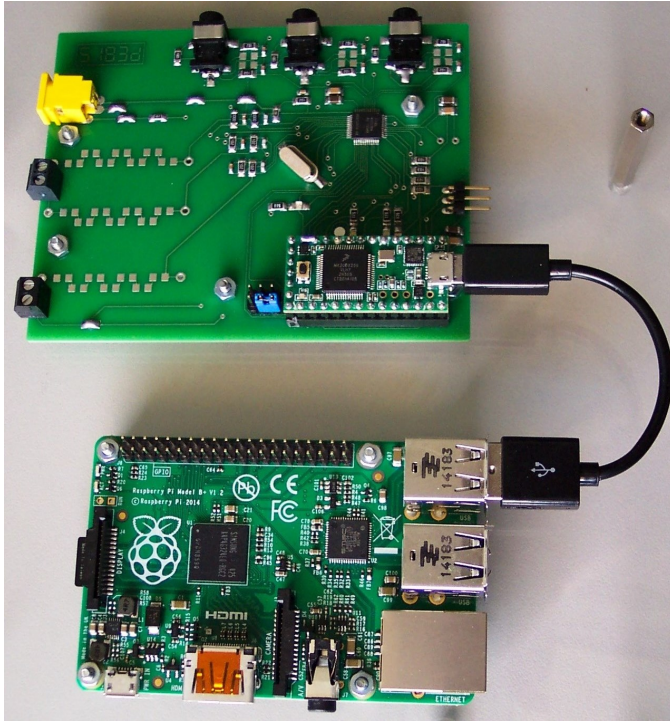


Fig. 1. The upper board represents the developed metering board, which contains the Teensy board, connected via USB to the Raspberry Pi (lower board).

A. Requirements

To transfer measurement data of three phases (current and voltage) in real-time and use them for load disaggregation algorithms, we calculated the following requirements for the smart meter, which we had to take into account for the selection of hardware components (discussed in the next subchapter):

- For load disaggregation, a sample frequency in kHz range is necessary: Because we apply a Radix-4 FFT algorithm for Fourier coefficient calculation, we need a number of complete signal periods fitting into 1,024 measurement data (maximum number of available field elements needs to be a power of 4) to achieve a good approximation for the harmonics. To fulfill this we chose a quartz oscillator, which provides a sampling rate of 7.324 kHz. Thus, 7 signal periods fit except for one value within 1,024 at a power line frequency of 50 Hz, what is a good sampling frequency for capturing integer multiples of 50 Hz in

the signal:

$$\frac{50 \text{ Hz} \cdot 1,024 \text{ values}}{7,324 \text{ Hz}} \approx 6.99 \text{ periods}$$

- Transfer rate from the measurement chip to the microcontroller:

$$\frac{32 \text{ bit} \cdot 1,024 \text{ values} \cdot 6 \text{ channels}}{7 \text{ periods} \cdot 0.02 \text{ s}} \hat{=} 1.4 \text{ Mbps}$$

- Transfer rate from the microcontroller to the Raspberry Pi:

$$\frac{32 \text{ bit} \cdot 41 \text{ coefficients} \cdot 6 \text{ channels}}{7 \text{ periods} \cdot 0.02 \text{ s}} \cdot \underbrace{2}_{\text{real and imaginary part}} \hat{=} 112.5 \text{ kbps}$$

- Microcontroller RAM size:

$$4 \text{ Byte} \cdot 1,024 \text{ values} \cdot 6 \text{ channels} \cdot 2 \text{ buffers} \hat{=} 49.1 \text{ kByte}$$

B. Metering Board

The purpose of the smart meter in our case is not to use it for utility billing but rather for performing load monitoring. Therefore no exact active power calculation is necessary, so we were enabled to use low cost measurement hardware components. On the other hand, a real-time transfer of data, measured at a sampling rate in kHz range, is required. Figure 2 depicts the system structure, which includes the following parts:

- *Low-cost measurement instruments:* We chose current transformers and voltage transformers, which make direct access to the power lines unnecessary (direct connection to the power lines can be used for voltage measurement, too).
- *Poly phase measurement chip:* A measurement chip reads current and voltage signals of up to three phases at a sampling rate in kHz range, so because of the Nyquist-Shannon sampling theorem frequencies in the signals up to the half of the sampling rate (Nyquist frequency) can be analyzed. After a market analysis of available analog front ends (cf. table I) we chose the ATMEL 90E36A smart meter chip, which is able to read current and voltage signals of up to three phases.
- *Real-time processing of measured data:* To match the requirement of real-time processing, we use a Teensy 3.1 microcontroller development system that features a MK20DX256 ARM Cortex-M4 with 72 MHz, 64 kB RAM memory, a SPI and an USB Port. This board is able to calculate the FFT fast enough and can send the Fourier coefficients via USB e.g. to a Raspberry Pi.
- *Wireless data transfer to a server:* A Raspberry Pi is used in our current setup to run the pattern recognition algorithm and to display the active devices on a website. In the future setup it will be used to transfer the measured data via wi-fi to a server, which provides galvanic isolation between potentially expensive server hardware and the measured power lines of up to 400 volts (in case of direct connection to the power lines).

TABLE I. RESULTS OF A MARKET ANALYSIS FOR POLY PHASE ENERGY METERING FRONT ENDS.

Model	Sampling rate	Datasheet
Ti EVM430-F6779	4 kHz	[3]
Maxim MAXQ3183	2.7 kHz	[4]
Atmel ATM90E36A	8 kHz	[5]

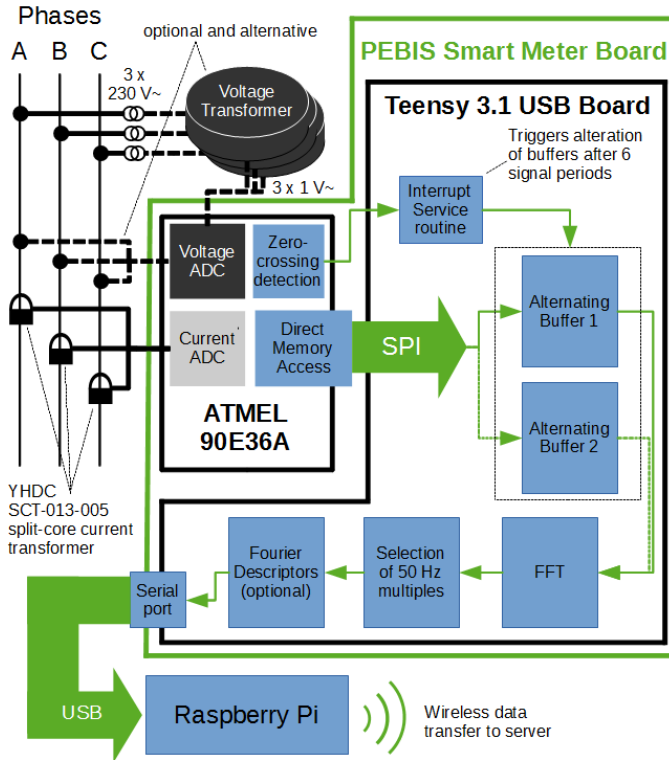


Fig. 2. Data acquisition and processing in the devised smart meter board.

The designed smart meter printed circuit board (PCB) front-end consist of three voltage inputs, each with a spark gap comprising seven serial resistors. To switch between voltage transformer and direct connection modes, a bridge has to be closed. On the upper bottom side, three 3.5 mm connection jacks are used to attach the current transformers to the board. All inputs are fed into a dedicated second order delta-sigma-ADC with 32 bit resolution. Besides the actual smart meter chip and the front-ends, the PCB contains a Teensy 3.1 USB board which is placed on standard 2.54 mm sockets. Therefore, it can be accessed and replaced easily. Furthermore, the PCB provides a separate serial connector to the Teensy which can be used as dedicated communication port, three visual indicators, four test-pads and two jumper pins for further testing and development.

The data generated by the measurement chip is gathered by the Teensy. Via the SPI bus, the Teensy sends the chip (in slave-mode) into direct memory access mode (DMA). Then - in master-mode - the chip sends the read current and voltage measurements directly over the SPI bus, where the Teensy collects them into two buffers of 2,048 values. One buffer is filled with the alternating current and voltage readings of each phase, while the second buffer is propagated to data preprocessing (cf. figure 3 and figure 4 for visualization of buffer change mechanism).

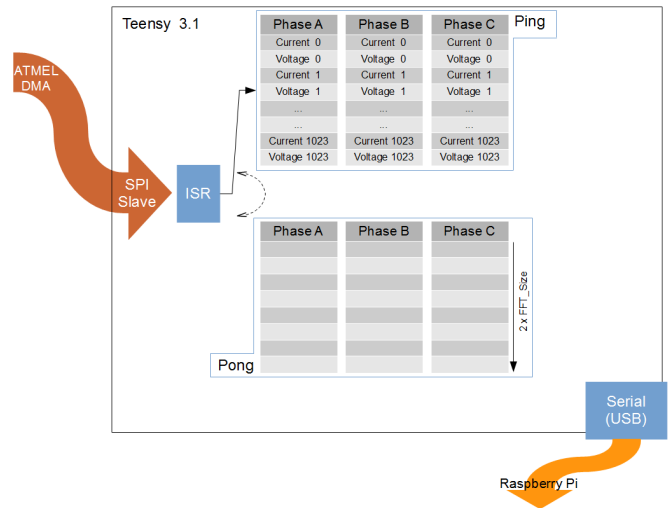


Fig. 3. Filling buffer Ping with measurement data.

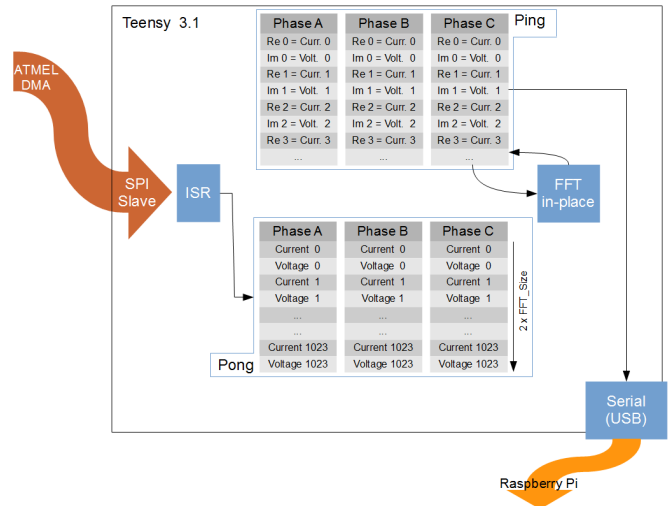


Fig. 4. While calculation FFT of buffer Ping, filling buffer Pong with measurement data.

For synchronizing the data, the ATME90E36A chip provides a zero-crossing signal for each phase via a zero-crossing detection pin, which propagates the start and finish of a period in the current or voltage signals. This pin is also read by the Teensy in an interrupt, which switches the data collection to the other buffer after the maximum number of full signal periods that fit within the 1,024 value limit have been read (in German power lines with 50 Hz, this results in seven periods being read). This approach fixes the measuring window to a full multiple of a current- and voltage period, allowing us to simply apply the FFT to the signal as-is, without the need for a window function and without distorting the spectral estimate. For processing the data, at first, a complex, in-place, fixed-point Radix-4 algorithm is used to calculate the FFT. Afterwards, the complex values of the Fourier coefficients are extracted and the fundamental and first 40 harmonics selected. Thus, the data can be read continuously (no fluctuation in the current and voltage signals is missed) and is reduced from 24,576 bytes (4 bytes · 1,024 values · 6 channels) to 984 bytes (real and imaginary part of the 40 harmonics plus the funda-

mental: 4 bytes · 41 coefficients · 6 channels).

Finally, the data is sent to a Raspberry Pi (or any other computer) over the USB-Port of the Teensy. There, the data can be transferred to a database server or directly be visualized, disaggregated or clustered.

The described smart meter is able to transfer high detailed signal information in short intervalls with the transfer of 41 harmonics every 0.14 seconds. These values characterize the signal a lot better for the purpose of load disaggregation than commercially available low cost smart meter do with transferring active and reactive power and root mean square values in intervalls of 1 second to several minutes.

C. Teensy firmware description

The firmware for the Teensy board was written with the Arduino IDE. In the following, the main code passages, which show the functionality of the code, are displayed first and explained in a few words directly below to describe the measurement and data processing of the smart meter.

```
void (setup) {
  ATM90E36_setup();
  FFT_pingpong = PING; }
```

In the setup function the measurement chip ATM90E36 is reset and initialized. At this point, the frame size is set to 32 bit and zero crossing detection is activated (provided by the measurement chip) via setting register parameters. The buffer PING is selected as the active buffer at the beginning.

```
void loop() {
  attachInterrupt(PIN_CS_IRQ, ISR_CSc, RISING);
  attachInterrupt(PIN_ZX0, ISR_ZeroDet, FALLING);
  digitalWrite(PIN_DMA_CTRL, HIGH);

  while(DataSampleComplete == 0);
  FFT_CALC(&fft_inst, DataPing1);
  RASP_sendFFT(DataPing1, 1);
}
```

In the main function, interrupts are attached to the chip select pin and the zero crossing detection pin. The ISR_CSc interrupt service routine, which is activated by the chip select signal, is used to indicate, when the measurement chip finished writing a new measurement data set of three current and three voltage measurements via SPI to the Teensy register. These data are copied to the data buffer, which is active at that moment. The buffer change mechanism is implemented here as well, which is detailed in the description of the corresponding service routine below. The ISR_ZeroDet interrupt service routine, activated by the zero detection signal, counts the number of zero crossings of the voltage signal. When a complete data set was written in the register, FFT is applied to this data set. Thereafter the calculated Fourier coefficients are sent to the Raspberry Pi.

```
void ISR_CSc(void) {
  if (FFT_pingpong == PING) {
    DataPing1[DataSample] = DataRaw[0];
    DataPing1[DataSample+1] = DataRaw[1];
    ...
    DataPing3[DataSample+1] = DataRaw[5]; }
  else {
```

```
    DataPing1[DataSample] = DataRaw[0];
    ...
    DataPing3[DataSample+1] = DataRaw[5]; }
  DataSample = DataSample+2;

  if (DataPeriode >= ZERO_PADDING_PERIODE) {
    DataPeriode = 0;
    DataSample = 0;

    if (FFT_pingpong == PING) {
      FFT_pingpong = PONG; }
    else {
      FFT_pingpong = PING; }

    DataSampleComplete = 1; }
}
```

The chip select cycle service routine ISR_CSc takes the task to sort the measured data to the active buffer Dataping or Datapong. After each cycle, an if statement checks for the number of falling zero crossings occurred in the voltage signal. If the zero crossing counter Dataperiode exceeds the predefined ZERO_PADDING_PERIODE variable, which is set to 7 periods, the buffer changes and the DataSampleComplete variable is set to 1. That indicates the main function to apply Fast Fourier Transform to the filled buffer, while new measurement data are written to the other buffer.

IV. VISUALIZATION

Besides the hardware development, we built a first version of a visualization platform to display the results of the appliance disaggregation, which is described next. At this, the instantaneous consumed electric power can be analysed as well, whose calculation is possible from the Fourier coefficients.

A. Analysis of Active Devices

The Fourier coefficients of the fundamental and the first 40 harmonics are sent to a Raspberry Pi via USB interface as a vector. This vector of 41 complex values gives us a fingerprint of the current device state in the frequency space. This permanently measured fingerprint gets compared with all reasonable aggregations of prepared fingerprints from the available devices. These prepared fingerprints, which represent the reference dataset of all known devices and device states, were measured manually in a first step and stored on the Raspberry Pi itself. In this first approach, also the appliance disaggregation is executed on the Raspberry Pi: For the reference data of each device state, the distances of the set of Fourier coefficient vectors to its mean Fourier coefficient vector are calculated to define cluster radii. If an instantaneous measured fingerprint is within one of the known clusters, the visualization indicates the recognized device state. For a more detailed explanation about the disaggregation algorithm, cf. our previous paper [12].

To visualize the detected device states and the amplitude spectrum of the Fourier coefficients, we have developed a visualization tool, which is shown in figure 5.

This demonstrator implements a html page, which uses java script code for drawing operations. The data to be displayed, is transferred in JSON format. The java script program then draws the amplitude spectrum as SVG graphic and pictures the detected devices as green filled circles.

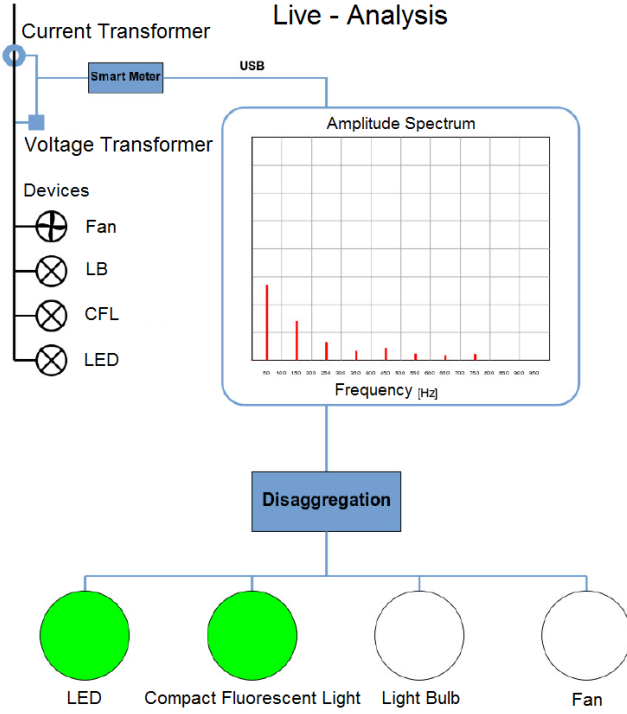


Fig. 5. Current development status of visual feedback system.

B. Analysis of Power

Additionally, the power demand of the connected devices shall be calculated. Usually smart meters integrate the product of instantaneous measured current and voltage over the time to calculate the active power. In our case, we do not transfer the raw measurement values, but only Fourier coefficients. With these, power values can also be calculated approximatively by the formulars developed in the following:

By using a simple transform, Parseval's theorem [11] can be formulated for complex-valued functions on \mathbb{R} with period $T > 0$ as

$$\frac{1}{T} \cdot \int_{-T/2}^{T/2} f(t) \overline{g(t)} dt = \sum_{k=-\infty}^{\infty} \widehat{f}_k \overline{\widehat{g}_k}.$$

There we have $\omega = 2\pi/T$, $f(x) = \sum_{k=-\infty}^{\infty} \widehat{f}_k \exp(j k \omega x)$ and $g(x) = \sum_{k=-\infty}^{\infty} \widehat{g}_k \exp(j k \omega x)$, which are square integrable functions with \widehat{f}_k and \widehat{g}_k as the Fourier coefficients of f and g , for illustration calculated as

$$\widehat{f}_k = \frac{1}{T} \int_{-T/2}^{T/2} f(t) \exp(-j k \omega t) dt.$$

If f and g are real valued functions on \mathbb{R} , this can be formulated as

$$\frac{1}{T} \cdot \int_{-T/2}^{T/2} f(t) \overline{g(t)} dt = \widehat{f}_0 \widehat{g}_0 + 2 \cdot \underbrace{\operatorname{Re} \left(\sum_{k=1}^{\infty} \widehat{f}_k \overline{\widehat{g}_k} \right)}_{= \sum_{k=1}^{\infty} \operatorname{Re}(\widehat{f}_k \overline{\widehat{g}_k})}, \quad (1)$$

because of $\widehat{f}_{-k} = \overline{\widehat{f}_k}$ and $\widehat{g}_{-k} = \overline{\widehat{g}_k}$. In our case, we use f as the voltage, in expression $f(t) = u(t)$ and g as the current, $g(t) = i(t)$. In stationary case, the current has a fundamental frequency of 50 Hz, given by the power line frequency (Germany). Because the voltage is purely sinusoidal (harmonic), also with fundamental frequency of 50 Hz, we observe $\widehat{u}_k = 0$ for $k \neq 1$, and formula (1) for **active power** calculation reduces to

$$P = \widehat{p}_0 = \frac{1}{T} \cdot \int_{-T/2}^{T/2} u(t) i(t) dt = 2 \cdot \operatorname{Re}(\widehat{u}_1 \overline{\widehat{i}_1}), \quad (2)$$

where $T = 0.02s$.

Another observation is, that formula (1) allows us to calculate the effective value (root-mean-square) of a T -periodic real-valued function f by using $g := f$, so that, in the case that the current is in stationary state, the **effective value** I_{eff} of current can be calculated as

$$\begin{aligned} I_{\text{eff}} &:= \sqrt{\frac{1}{T} \int_{-T/2}^{T/2} i(t)^2 dt} \\ &= \sqrt{|\widehat{i}_0|^2 + 2 \cdot \sum_{k=1}^{\infty} |\widehat{i}_k|^2}. \end{aligned} \quad (3)$$

Because of the limitation given by the Nyquist-Shannon sampling theorem, if f_{sam} is the sampling rate, the maximal number M of Fourier coefficients can be calculated as

$$M = \left\lfloor \frac{f_{\text{sam}}/2}{50 \text{ Hz}} \right\rfloor.$$

In the following formulars, the summation operator has the upper limit ∞ , which can be replaced in practical cases with the summation operator with the upper limit M , in expression: replace $\sum_{k=\dots}^{\infty}$ with $\sum_{k=\dots}^M$. E.g. (3) goes to

$$I_{\text{eff}} = \sqrt{|\widehat{i}_0|^2 + 2 \cdot \sum_{k=1}^M |\widehat{i}_k|^2}. \quad (4)$$

The **reactive power** Q , caused by phase shift, can be calculated as

$$\begin{aligned} Q &= 2 \cdot \operatorname{Im} \left(\sum_{k=1}^{\infty} \widehat{u}_k \overline{\widehat{i}_k} \right) \\ &= \sum_{k=1}^{\infty} \operatorname{Im}(\widehat{u}_k \overline{\widehat{i}_k}) \end{aligned} \quad (5)$$

and in our case it reduces to

$$Q = 2 \cdot \text{Im} \left(\widehat{u}_1 \widehat{i}_1 \right). \quad (6)$$

The **apparent power** S is defined as

$$S = U_{\text{eff}} \cdot I_{\text{eff}}. \quad (7)$$

Using formula (3) and the observation that $\widehat{u}_k = 0$ for $k \neq 1$, it follows that

$$S = \underbrace{\sqrt{2} |\widehat{u}_1|}_{=U_{\text{eff}}} \cdot \sqrt{|\widehat{i}_0|^2 + 2 \cdot \sum_{k=1}^{\infty} |\widehat{i}_k|^2}. \quad (8)$$

The **total reactive power** Q_{total} is given by

$$\begin{aligned} Q_{\text{total}} &= \sqrt{\underbrace{U_{\text{eff}}^2 \cdot I_{\text{eff}}^2}_{=S^2} - \widehat{p}_0^2} \\ &\stackrel{(8)}{=} \sqrt{\underbrace{2 |\widehat{u}_1|^2}_{=U_{\text{eff}}^2} \cdot \left(|\widehat{i}_0|^2 + 2 \cdot \sum_{k=1}^{\infty} |\widehat{i}_k|^2 \right) - \widehat{p}_0^2}. \end{aligned} \quad (9)$$

where the active power \widehat{p}_0 is given by formula (2).

The **deformed power**, which is caused by the harmonic components in the signal, is given by the following formula

$$Q_d = \sqrt{Q_{\text{total}}^2 - Q^2}. \quad (10)$$

These overall power values in combination with the detected device states can provide a feedback about energy savings of implemented energy efficiency measures.

For an accurate power measurement, the measurement instrument's property to provoke a phase shift in the measured signal had to be considered, which is not there in original state of the signal. Therefore, we compared the signal output of the current transformer, measuring an ohmic resistance, to the measured signal of a smart meter, which uses a shunt resistor for current measurement. Furthermore, the output signal of the voltage transformer has been evaluated by comparing to the grid voltage signal. As a result, the positive phase shift of both the current transformer and the voltage transformer has to be corrected through the metering software.

By this means, we were able to calculate active and reactive power values, which corresponds to the output values of a commercially available wattmeter.

V. CONCLUSION AND OUTLOOK

With the developed smart meter we met our requirements for appliance disaggregation, which we run at this time with different types of lights (LED, compact fluorescent light, light bulb), fans and a mobile air conditioner. Such a smart meter, which provides centralized data acquisition and appliance disaggregation via pattern recognition algorithms, also avoids to equip every single electrical device with an electricity meter. Installed e.g. in the distribution box, this represents a cost-efficient method for load monitoring.

Further algorithm development can improve appliance state analysis, which includes the detection and allocation of unknown and known device errors. Also a disaggregation and allocation of the calculated power values to the detected devices has to be implemented.

The visualization platform can be extended at the point of visual preparation of results and error messages and options for displaying power curve, signal shape (by reconstruction from Fourier coefficients) or spectral envelopes in cases of transient signal events. This can provide important information about the operation states of machines, technical workplaces or residential buildings, where the smart meter can be applied. The focus of further research will be on these aspects.

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Transaction Analysis

A mechanism to detect and prevent VAT-fraud in the European Emissions Trading System (EU ETS)

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Abstract—The European Emissions Trading System (EU ETS) has been shown vulnerable to VAT-fraud. Due to the introduction of the Reverse-Charge-Procedure in the majority of EU Member States (MS), VAT-fraud has reduced significantly. Nevertheless, remaining VAT-fraud patterns need to be detected in the transactions in order to support investigation bodies. On the basis of the Belgium software REMa the National administrators of Germany, France and United Kingdom have developed a method to detect VAT-fraud, called Transaction Analysis. This method is explained. Transaction Analysis has been validated against historical data.

Keywords—*European Emissions Trading System; VAT-fraud; Transaction Analysis; fraud detection;*

I. INTRODUCTION

The European Emissions Trading System (EU ETS) has been introduced in 2005 in all European Member States. It was the first ETS on supranational level. It was designed on basis of the European law [1, 2] and as a decentralized system with strong responsibility of the European Member States (MS).

In 2009 and 2010 the EU ETS was under massive attack by criminals. They abused the simple and elegant mechanism for transferring assets between MS boundaries for VAT fraud. Due to the legal situation at that time it was extremely difficult to prohibit this kind of fraud. EUROPOL and Interpol have estimated losses of up to € 5.5 Billion for the tax systems of the affected MS.

The European Commission (Cion) and the MS took countermeasures by changing the legal basis (introduction of a Reverse-Charge-Procedure) and developing mechanisms to detect fraudulent activities. One mechanism will be explained here, the **Transaction Analysis**. It has been developed in a close cooperation by the National Administrators of Germany¹, France², United Kingdom³ and their respective law, tax and financial authorities. Other National Administrators, in

particular Belgium⁴ by giving access to the software REMa, have contributed to this development.

This article explains the methods for detecting VAT-fraud in patterns of EU ETS transfers and discusses initial results.

II. METHOD

A. The European Emissions Trading System

The Emissions Trading Registry (registry) is the heart of any ETS. It is a database software application that is similar to an online banking system. The participants of the ETS (industries, power provider, brick or steel manufacturer, banks, traders, private persons ...) have accounts in the registry. They can hold units of different types on their accounts. In the EU ETS the most important one is the European Allowance (EUA). Other unit types are

- Aviation Allowances (aEUA or EUAA) for the aviation sector
- Certified Emission Reduction Units (CER generated by CDM-projects)
- Emission Reduction Units (ERU generated by JI-projects)
- Removal Units (RMU) for sinks of greenhouse gases like forests

Account holders can perform several actions with units held in their accounts. It is possible to transfer units to another account (e.g. as fulfilment of a purchase contract). It is also possible to cancel units (for compensation of greenhouse gas emissions) and to surrender units (fulfilling the obligation in the EU ETS). As the EU ETS is an economical system for the limitation of greenhouse gas emissions the trading of units is the core part of it.

At the beginning of the EU ETS each MS was obliged to maintain its own registry. These registries were connected by the Community Independent Transaction Log (CITL) at the European level (CITL until 2012 and EU Transaction Log

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² Caisse des dépôts et consignations (CDC)

³ Environment Agency

⁴ Service Public Fédéral - Sant Publique, Securite de la chaine Alimentaire et Environment

EUTL since then) and by the International Transaction Log (ITL) at the Kyoto level (ITL⁵, maintained by the climate secretariat of the UNFCCC). Further explanations of the network of registries and transaction logs may be found at the websites of the United Nations Climate Secretariat⁶ (UNFCCC) and the German Emissions Trading Authority⁷ (DEHSt). Since 2012 all European registries are consolidated in the Union Registry (UR) maintained by the European Commission.

Operators with installations falling under the EU ETS are required to open an account in the registry in order to fulfil their legal obligations. Other private entities and persons may open trading accounts on a purely voluntary basis. During 2009 and 2010 the National Administrators experienced rapidly growing number of transactions and volumes in their registries. Rather soon it became evident that these transactions were not legitimate but were indicators for VAT-fraud. The National Administrators do not have access to the underlying financial transaction which soon became clear to be a limiting restriction. In 2010 most MS introduced the Reverse-Charge-Procedure and VAT-fraud stopped almost immediately in these countries. With the Reverse-Charge-Procedure the buyer and not the seller is discharging the tax.

B. Patterns of VAT Fraud

VAT fraud is a common method of fraud well known from areas where expensive goods can be transported easily over boundaries (mobile phones, Integrated Circuits ...). The basic principle of VAT fraud is shown in figure 1.

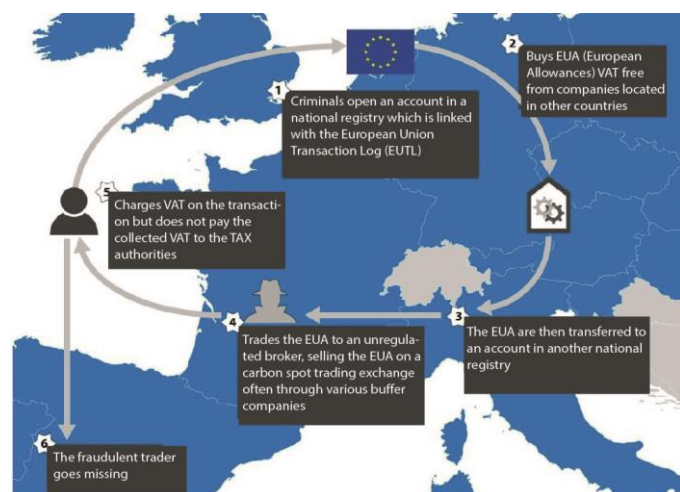


Figure 1 - Carrousel or VAT-fraud

The fraud is performed by several companies that trade (very often there is no real trade and no flow of money) a commodity in circles. There is one trader in the chain that is obliged to pay the VAT but it will disappear after a while without doing so (this fraud is therefore also called missing-

trader fraud). Others in the chain claim money from their tax authorities due to their right of deduction of input tax.

ETS has been abused for VAT-fraud, because it is easy to handle. Companies can open accounts in all European registries and access the systems via the Internet. The emissions allowances, the main commodity to be dealt with in the EU ETS, can be transferred from one account to the other instantaneously.

Very typical patterns of VAT-fraud are:

- The account balance is almost always 0
- Whenever a number of units are received, they are transferred away almost immediately
- Transfers are almost always international (e.g. DE to UK)
- The same units are coming back to the account after having transferred out
- Small and newly founded companies are trading huge amounts of units worth huge amounts of money
- The transfer paths are similar to identical

C. Transaction Analysis

The central method of detecting VAT-fraud activities is the Transaction Analysis (TA). It consists of a bundle of statistical and empirical methods. The combination of these methods may result in a clear indication on VAT-fraud.

The behaviour of market participants is shaped by their specific activities. A small paper manufacturer, for example, would receive a free allocation once per year (until 28 February) from the corresponding National Administrator. The deadline for surrendering (fulfilment of the operator's legal obligations) is 30 April. The paper manufacturer may easily establish if he needs to purchase further units to meet this obligation. He would do that by contacting banks or other operators under the EU ETS. After having received the further units he would surrender them in time, and probably forget about the EU ETS until the end of the year.

Other operators like big power providers use emission allowances like any other asset (energy, heat, coal, gas) and trade them on a daily basis. However, important in this context is the observation, that different groups of participants do show specific patterns of behaviour in their transactions.

As described in the preceding chapter we found typical historic transaction patterns indicating VAT-fraud. The main part of TA consists of a statistical comparison of the transaction behaviour of a specific account with the "average behaviour" of the group the account belongs to. We do not explain in detail in which way this "average behaviour" is being computed, because this could give an indication how to avoid detection by the algorithm.

As a second part we compare the transaction behaviour within a certain time frame (e.g. 12 months) with the behaviour in the preceding time frame. This is based on the assumption that it is unlikely that non-criminal market

⁵ https://unfccc.int/kyoto_protocol/registry_systems/itl/items/4065.php

⁶ <http://unfccc.int/2860.php>

⁷ http://www.dehst.de/EN/Service/Union-Registry/Union-Registry_node.html

participants would change their behaviour in time drastically. And if market conditions do change, the change in behaviour can be seen from all market participants (and all account groups) in almost the same way. Typical examples of accounts with strange and suspicious behaviour can be seen in figure 2 and 3.

Another important aspect of TA is the tracking of units. In the EU ETS units have unique serial numbers. Therefore it is possible to follow their path from one account to the other. The ordinary user cannot see the serial numbers and it is therefore not possible to choose specific units for a transfer. The system chooses the units almost randomly. It is therefore extremely unlikely that a unit will come back several times to one specific account. We have seen units coming back up to 63 times per day in 2009 over identical paths. There is no business case that fits with such high speed trading. The only explanation is that the units are being transferred in closed loops several times and that all units that just arrived at the account are transferred out immediately (before other incoming units could mix up).

Third part of the TA is the evaluation of the transaction behaviour in time. In the EU ETS there are fixed dates for specific actions of the operators or other market participants:

- 28 February: free allocation
- 30 April: surrendering
- 1 December: Delivery of futures contracts

In figure 2 we compare transactions of a typical operator in the EU ETS with the transactions of a convicted fraudster in Germany.

The left diagram shows unsuspicious behaviour. The green bars represent the mean values of the account group. The red bars represent one specific account out of this group. As we can see the extremes are more prominent, but in general the course of transactions show peaks at the same time.

The right diagram shows suspicious behaviour. Again, the green bars represent the mean values of the account group. The red bars show the figures of a known and convicted criminal. Peaks do obviously not occur at the right time and are of magnitudes away from ordinary behaviour.

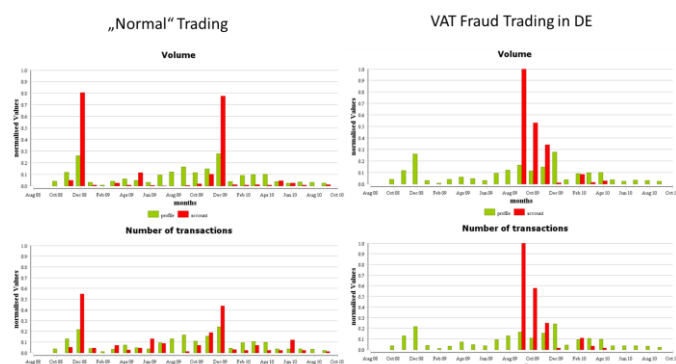


Figure 2 – Transactions in time. Green bars: mean values for the group, red bars: specific account values.

D. Software Implementation

Transaction Analysis is a complex method that shows Indicators for potential fraud in the transactions of a registry. It is based on statistical analysis of transaction data. This data comes from the Union Registry⁸, the central registry of the EU ETS [2]. The data sets are exported on a regular basis for the European Member States.

On the basis of the REMa⁹ software, a module called GYM (German Transaction Analysis Module) has been developed¹⁰. REMa is a database application for the support of administrative procedures of the MS National Administrators. Within REMa data that is needed for the day-to-day management of the accounts in the UR can be administered. GYM is an optional module that is currently used by Germany for systematic transaction analysis and that is currently under test procedures in some other MS.

E. Validation of the Methodology

In order to validate the methodology, we have tested the software with data from the German Emissions Trading Registry. In 2009 and 2010 we have seen VAT-fraud in Germany and since then several court cases have been processed and people have been found guilty for VAT-fraud. We tried to find out whether the TA is able to identify the fraudulent activity on the accounts of these companies.

The result is shown in figure 3. The bubble diagram at the left side shows the volume of transactions, the one on the right side shows the number of transactions. The size of the bubbles corresponds to the respective parameter. At the X-axis the distance to the profile is shown. At the Y-axis the distance to the previous period is plotted. The nearer to the upper right corner a bubble is plotted; the bigger is the deviation from the group and the previous time period. The bubbles indicated by arrows represent the accounts of convicted fraudsters.

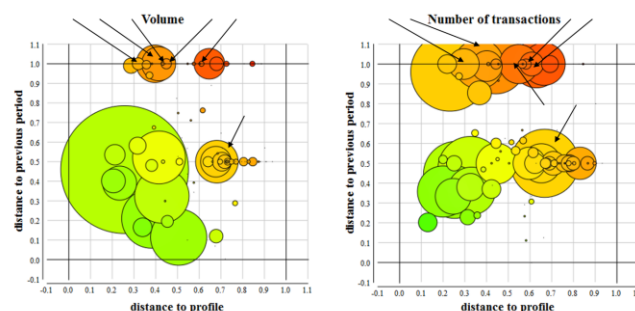


Figure 3 – Bubble diagram on transaction behaviour in relation to the group's mean behaviour. Arrows indicate convicted fraudsters.

⁸ http://ec.europa.eu/clima/policies/ets/registry/index_en.htm

⁹ REMa has been developed and licensed by the Federal Public Service (FPS) Health, Food Chain Safety and Environment DG5 Environment, Climate Change Division of Belgium

¹⁰ Developer is Dr. Lippke und Dr. Wagner GmbH, Berlin

III. RESULTS, CONCLUSIONS AND FURTHER STEPS

The Transaction Analysis is a method for detecting patterns of VAT-fraud in transactions of the EU ETS. We have been able to validate the method against historical data.

VAT-fraud in the EU ETS has become almost impossible in most of the MS due to the introduction of Reverse-Charge-Procedure [3]. Nevertheless, there are still many suspicious cases in the past that are to be analysed and to be brought to court. Additionally, MS where no Reverse-Charge-Procedure has been introduced still have the potential for future VAT-fraud.

TA is not yet implemented in the day-to-day management of all National Administrators. Discussions are ongoing and some MS believe TA should be performed centrally. This position is reinforced by feedback from several MS Financial Intelligence Units as well as the recent EU Court of Auditors report¹¹. Performing TA centrally would improve the oversight and coordination of any investigation of VAT-fraud, especially as they are almost exclusively of an international character.

Article 98 of the Registry Regulation [2] also focuses on money laundering and terrorist financing. Money laundering is a topic that needs further attention. It seems to be more challenging than VAT-fraud, especially because the National Administrators cannot see the money flow behind the transactions of EU ETS units. The German Emissions Trading Authority plans to start a research project on detection of money laundering in the EU ETS in the coming year.

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Austrian AQD e-Reporting via INSPIRE Services

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Abstract— To comply with the recently issued AQD e-Reporting data standards by the European Commission (EC) and the European Environment Agency (EEA), the Austrian Environment Agency (EAA) has, together with the Austrian Institute of Technology (AIT), started the development of INSPIRE compliant download services supporting the full requirements of air quality reporting under European Air Quality Directive 2008/50/EC (AQD). Thus, the Austrian air quality data measured under legal requirements, together with the corresponding measurement metadata and reporting relevant information, will soon be available via real time web-services. One difficult question encountered was which INSPIRE download services to use for which of the features encompassed by the reported datasets. For data flow on air quality zones (B) as well as on air quality assessment metadata (D) it was clear that we would provide these data via a Web Feature Service (WFS), namely the OGC compliant implementation GeoServer. For the data flows C (assessment regime) and G (attainment,) which are purely reporting relevant data, we chose to also use the WFS option for simplicity. For the primary air quality data provided under data flow E we decided to use a Sensor Observation Service (SOS), as this service is far better suited for the provision of time series data. However, there is an area of overlap between the two services, pertaining to the measurement metadata. As the features provided by both services are identical, and the only difference in the response being the service response wrapper, the SOS forwards the request to a coupled WFS, and re-wraps the response before providing it to the client. The SOS used in this solution is a new implementation based on the openUwedat-Framework developed by AIT [1]. This framework provides a harmonized way to wrap virtually any source of time series data by configuring a data handler in a documented way. In addition, the framework is able to deal with semantic information pertaining to individual time series [2] to dynamically influence the fields that should be included in the SOS output such as data quality.

Keywords— INSPIRE, OGC Download Services; SOS; WFS; Air Quality reporting; Ambient Air Quality Directive; GeoServer

I. INTRODUCTION

Triggered by the new AQD e-Reporting data standards recently issued by the European Commission (EC) and the European Environment Agency (EEA), the Austrian Environment Agency (EAA) has initiated the establishment of INSPIRE compliant download services supporting the full requirements for air quality reporting under European Air Quality Directive 2008/50/EC (AQD), the 4th Daughter Directive 2004/107/EC and explicitly specified in 2011/850/EU. This led to a co-operation with the Austrian Institute of Technology (AIT), a long term partner of the EAA

both in the development of technical solutions with environmental scope as well as in European research projects such as the Sany IP [3] that provided the first prototype for SOS base air quality reporting.

II. BACKGROUND

A. Air Quality Directive

The Air Quality Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (AQD) foresees the provision of air quality reporting data utilizing the data specifications and services specified by the INSPIRE Directive (2007/2/EC). Detailed specifications of the structure of reported information (“e-Reporting”) are laid down in the Decision 2011/850/EU (for short AQD IPR). E-Reporting under the AQD has begun with the reporting cycle starting in 2014. Data and information according to 2008/50/EC and 2004/107/EC have to be provided as XML files to ReportNet (CDR) following the timetable laid down in 2011/850/EU. In addition, starting in October 2015, this same data must be provided via INSPIRE compliant services.

The following data flows have been defined to cover the requirements of 2011/850/EU:

(B) Information on zones and agglomerations (Article 6): metadata about type and delimitation of zones established for the purposes of air quality assessment and management;

(C) Information on the assessment regime (Article 7); (meta)information on the assessment regime to be applied for each pollutant which includes fixed measurements and may include indicative measurements, modelling and objective estimation;

(D) Information on the assessment methods (Articles 8 and 9); detailed descriptions of the assessment methods applied including meta-information about the measurement or analytical technique for each pollutant, about the station and, the network;

(E) Information on primary validated assessment data (E1a) and primary up-to-date assessment data (E2a) (Article 10);

(F) Information on generated aggregated data (Article 11); this information will be generated by the EEA and made available to the Member States (MS);

(G) Information on the attainment of environmental objectives (Article 12) in each specific zone or agglomeration, including information on the exceedance of any applicable margin of tolerance;

(H) Information on air quality plans (Article 13);

(I) Information on source apportionment (Article 13);

(J) Information on the scenario for the attainment year (Article 13);

(K) Information on measures (Articles 13 and 14);

The datasets H to K covering AQ management information are not covered by e-Reporting, but should be provided by a web-interface developed by EEA and JRC. Thus in this article only data flow B-G are in the focus.

In addition, for each data flow a reporting header must be provided. This feature class is used to provide basic information on the data being provided within one data flow as well as to identify which instances are contained within this delivery. In addition to the basic administrative information contained directly within the AQD_ReportingHeader class, the content association is used to provide a link (xlink) to the individual AQD feature instances being reported.

Data flows B, C and D shall be reported as a forwarding looking report by 31 December for the following year as well as together with data flows E1a (validated data for a full calendar year as complete time series) and G as a retrospective report by 30 September for the previous year.

B. INSPIRE

The INSPIRE Directive entered into force on the 15th of May 2007. It recognizes that Community policy on the environment must aim at a high level of protection taking into account the diversity of situations in the various regions of the Community. It also stipulates that integrated information, including spatial information, is needed for the formulation and implementation of such policies.

The Infrastructure for Spatial Information in the European Community (INSPIRE) should assist policy-making in relation to policies and activities that may have a direct or indirect impact on the environment.

INSPIRE is based on the infrastructures for spatial information that are created by the MS and that are made compatible with common implementing rules and are supplemented with measures at Community level. These measures should ensure that the infrastructures for spatial information created by the MS are compatible and usable in a Community and trans-boundary context.

While the basic INSPIRE data specifications consciously do not take reporting requirements into account as this would create an additional administrative burden in the case of changes in legislation, they are built in such a manner as to allow for extension for reporting purposes. Annex F of the INSPIRE Generic Conceptual Model describes how the INSPIRE data specifications can be extended in order to support other purposes while maintaining the INSPIRE requirements. Thus, data provided using an INSPIRE based

extended data specification can be used to fulfill obligations stemming from both INSPIRE as well as a thematic reporting requirement, thus reducing the burden on MS data providers.

The AQD e-Reporting data model has been designed based on the INSPIRE data specifications. The UML data models created by the INSPIRE Thematic Working Groups (TWG) have been extended to support all requirements stemming from the IPR; these data models have then been used to generate the AQD e-Reporting schemata. The INSPIRE Annex III data specifications, that are of specific relevance to the provision of air quality data under the AQD, are in the process of finalisation.

At the present time, information on the INSPIRE based AQD e-reporting data model is available only from the EEA Air Quality (AQ) Portal [4]. This information includes UML diagrams, presentations on the data model, a mapping file showing the correspondence between the individual elements of data flows B-G to the data model as well as preliminary XSD schema files.

Further background information is also available from the INSPIRE data specification on Environmental Monitoring Facilities which provides the basis for the AQD e-reporting data model as well as the Guidelines for the use of Observations & Measurements (O&M) and Sensor Web Enablement-related standards in INSPIRE Annex II and III data specification development.

The core of O&M defines an observation (see Fig. 1) by specifying what is being measured (observedProperty = the pollutant), where is it being measured (featureOfInterest, the sample of air) and how is it being measured (procedure).

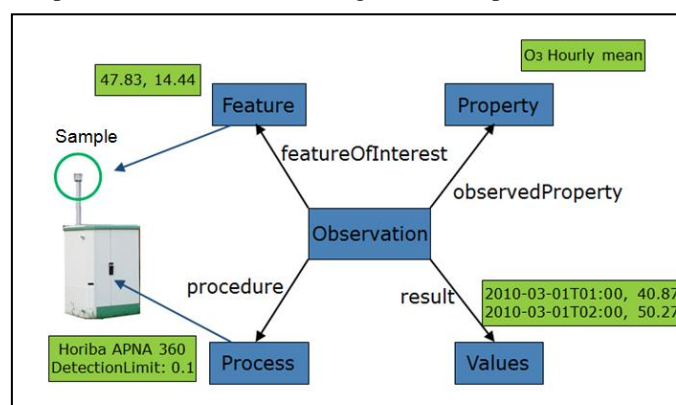


Fig. 1. O&M core model

C. Web Services

The INSPIRE Directive states that infrastructures for spatial information in the MS should be designed to ensure that spatial data are stored, made available and maintained at the most appropriate administrative level; that it is possible to combine spatial data from different sources across the Community in a consistent way and share them between several users and applications. Since the wide diversity of formats and structures in which spatial data are organised and accessed in the Community hampers the efficient formulation, implementation, monitoring and evaluation of Community legislation that directly or indirectly affect the environment,

implementing measures should be provided for in order to facilitate the use of spatial data from different sources across the MSs. Network services are necessary for sharing spatial data between the various levels of public authority in the Community. Those network services should make it possible to discover, transform, view and download spatial data and to invoke spatial data and e-commerce services.

III. SYSTEM OVERVIEW

A. Basic decisions on the architecture

Most of the Austrian air quality data to be exposed via INSPIRE compliant web services are available in an existing environmental data system called “UWEDAT”, which was developed by the Austrian Institute of Technology (AIT) and is operated by EAA.

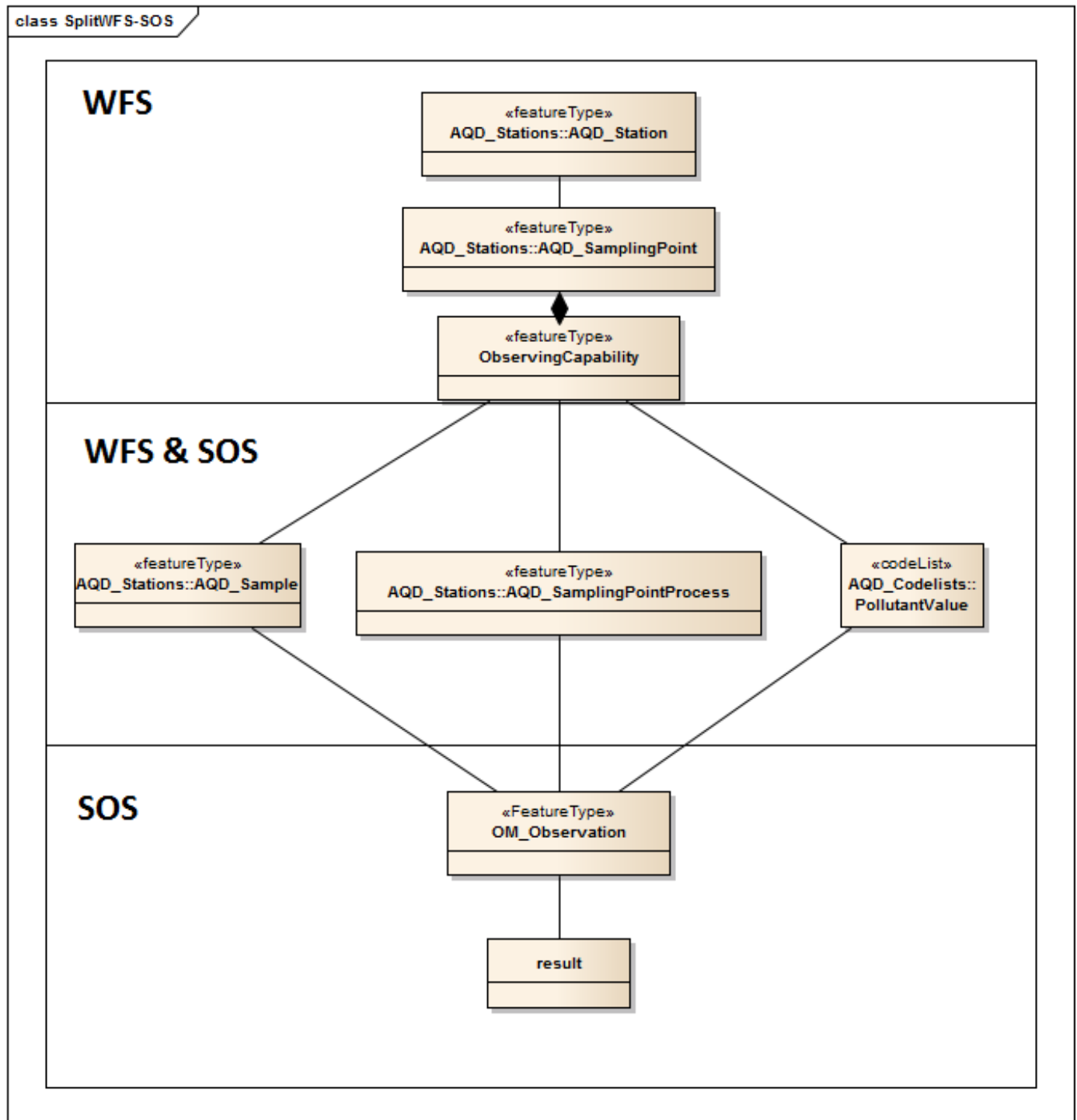


Fig. 2. Overlap between the two Download Services

UWEDAT is the database for EAA's AQ monitoring network (with near real-time (NRT) data transmission on half-hourly basis) and collects data from all federal air quality networks in Austria; it serves as a national repository for Austrian air quality data. UWEDAT's dataset reflects the status quo of the network; information on previous measurement metadata is limited, however, for years before 2010. The UWEDAT air quality monitoring system is an integral component of the air quality monitoring process in Austria; due to this central role of the system, stability must be assured at all times. Thus, one of the requirements was to keep the impact of INSPIRE on the UWEDAT System as low as possible.

Two consequences stem from these facts:

1. The measurement metadata to be published should be stored in a separate system only loosely coupled to the UWEDAT system. In order to assure consistency this system must be updated on a regular basis.
2. This system should also manage the versioning of older data.

This separate system will run on an isolated computer and will only have access to its own database. In the course of this paper the new system will be called the Air Quality Data system, for short "AQD system".

For the provision of measurement metadata, it was clear that we would select one of the existing open source products, and transfer the data to be served under INSPIRE and AQD e-Reporting to a dedicated database aligned both with the AQD e-Reporting data models as well as the requirements of the WFS server. Measurement metadata are transferred from the UWEDAT system to the AQD system at certain points in time, whereby within the reporting context the most relevant time for updates is every time a report is due according to 2011/850/EU. This transfer is the last step of the report preparation process. It is manually triggered and the final quality-control is performed by the responsible air quality data expert.

Each time a new report is created, a new version-controlled set of records is produced in the AQD system. Provisions have been made to enable the removal of erroneous reports and ensuing versions from the system.

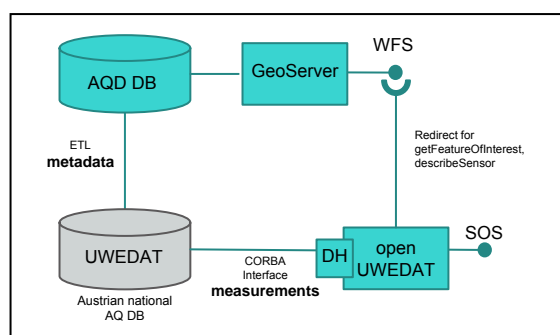


Fig. 3. System Overview

Moreover, it was clear that in addition to the Web Feature Service "WFS" commonly used within INSPIRE for the provision of spatial data, a Sensor Observation Service "SOS" would also be required as this provides far better access to time-series data, and fulfills the requirements set down by INSPIRE. However, we faced the question of how to assure complete synchronization between the two different services, as certain portions of the data to be served need to be included within both services in order to give a complete view on the data being provided (see Fig. 2). After looking at various synchronization options, we came to the conclusion to solve this problem with simple redirect logic (see also Fig. 3).

With the only difference between the WFS and SOS response being the response wrapper, the decision was reached to reuse this data between the systems. Instead of also maintaining a complete copy of the measurement metadata within the SOS server data source, the SOS only directly accesses the "original" measurement data from the UWEDAT system, assuring that the measurement data are as up to date as possible. Requests pertaining to measurement metadata, such as information on the measurement process as well as on the object of measurement, are redirected to the coupled WFS service. The SOS request 'describeSensor' relates to a WFS request for the featuretype AQD_SamplingPointProcess, 'featureOfInterest' does the same for AQD_Station (see again Fig.2). The WFS response is then transformed to an SOS response and returned to the original requester.

Fig. 3 gives insight in the interaction of the different components used in the solution and described below.

B. UWEDAT

The UWEDAT system is an existing environmental database system used to administrate and store measurement data and metadata. The measurement metadata are stored in a schema of an Oracle database in a relational model. Measurement data are also stored in tables of the same schema but for performance reasons data are packed into a binary format optimized for time-series, that stores multiple measurement data together with quality information.

Reading and writing of this format is only possible by using a special interface which is available implemented in different technologies. For this use case an interface based on CORBA was chosen.

C. AQD database

The AQD database is a set of tables and views, structured to allow efficient provision of air quality measurement metadata via INSPIRE compliant services. The tables and views defined are aligned with the requirement of the GeoServer WFS server. It is hosted in the same ORACLE database as the UWEDAT database but uses an isolated schema. The data are regularly updated using the mapping process (see below) to assure alignment between the data sources; no data are directly shared between the two schemas, the WFS always provide data from this cached version.

D. The mapping process

The UWEDAT schema is used to prepare and provide all measurement metadata which is to be delivered for a report. Once the data are ready for publishing, a special mapping process (using ETL procedures) is used to convey data from the UWEDAT schema to the AQD schema; this is shown in Fig. 3 under the point ETL metadata.

This process is not merely used to copy the data but also makes substantial format changes. As a result the data are provided in a form that is optimized for good performance access by the GeoServer (see below). As a side effect this often means that data are duplicated and not stored in a strictly normalized form.

E. GeoServer (WFS)

A GeoServer (currently version 2.7.0) is used to provide data via a WFS service. In the off-the-shelf configuration GeoServer only provides so called “simple features”, i.e. flat structures which do not allow nesting of subordinated data. On the other hand INSPIRE calls for complex structures and very often needs to nest multiple subordinate data blocks within a single feature.

```
<wfs:member>
<aqd:AQD_ReportingHeader gml:id="RHE.B.2014">
  <aqd:change>true</aqd:change>
  <aqd:changeDescription>
    all records are included, updated ones and not
    modified ones
  </aqd:changeDescription>
  <aqd:inspireId>
    <base:Identifier>
      <base:localId>RHE.B.2014</base:localId>
      <base:namespace>AT.0008.20.AQ</base:na
      mespace>
      <base:versionId>2014_15.02.2014</base:vers
      ionId>
    </base:Identifier>
  </aqd:inspireId>
  ...
  <!-- The following aqd:content-element comes
  several times and is nested in a separate table -->
  <aqd:content
    xlink:href="AT.0008.20.AQ/ZON_AT_00"/>
  <aqd:content
    xlink:href="AT.0008.20.AQ/ZON_AT_00_As"/>
  <aqd:content
    xlink:href="AT.0008.20.AQ/ZON_AT_00_Ni"/>
  <aqd:content
    xlink:href="AT.0008.20.AQ/ZON_AT_00_Pb"/>
  <aqd:content
    xlink:href="AT.0008.20.AQ/ZON_AT_01"/>
  ...
</aqd:AQD_ReportingHeader>
</wfs:member>
```

Fig. 4. Nested elements within a single feature

This requirement makes it necessary to use the app-schema plug-in, in order to provide the complex feature types required by INSPIRE. INSPIRE also calls for the extension of GeoServer’s GetCapability response to support concepts such as the language provided. The GeoServer WFS uses the AQD database to access the information it publishes.

F. openUWEDAT (SOS)

The decision that measurement data have to be retrieved directly from the original data store UWEDAT without any synchronisation makes the use of some of the more established SOS products difficult. The SOS Server from N52 [5] has no documented way to replace the provided database by another one; the same is true for the istSOS [6]. No exhaustive study of available source code has been made, so it is possible that one or both of the mentioned products can work with other data sources, but based on the previous experiences within both the Sany IP as well as various other research projects, the decision was reached to develop a new SOS based on AIT’s Open-UWEDAT technology.

openUwedat uses an extension mechanism to tap into other systems by using so called “data handlers” (DH).

Such a data handler has been implemented in order to provide direct access to the measurement data stored in the UWEDAT system. This task included the adaptation of the following data handler methods:

- Setter methods to parameterize data source connection;
- Open & Close methods;
- Filter methods to specify a specific data point (~ ObservingCapabilities);
- Method for getTimeSeries.

A TimeSeries class for the provision of time-series data has been configured in accordance with data formats required under AQD eReporting. Relevant contextual information providing additional metadata pertaining to the measurement data, such as data quality information, is automatically added to the measurement data as foreseen by the O&M data model.

The decision to implement a new SOS also gave us the flexibility to solve the synchronization problems between the data sources for the WFS and SOS servers by using redirects between the servers as mentioned above, providing a new solution to this difficult issue.

IV. GEOSERVER OPEN ISSUES

- One of the open issues that exists with the GeoServer app-schema plug-in is that it needs XML-elements when constructing a mapping. This restriction makes sense with features that are published to the outside but is somehow inflexible for the internal mapping. The AQD schema asks for nested parts which are repeated multiple times but are only defined as complex types, not elements. Nested elements with an unknown number of repetitions can only be solved with the

app-schema plug-in with separate mappings and the so called feature link mechanism. For that you need an extra “FeatureTypeMapping” which can only be given on XML-Elements, not complex types.

```

<aqd:AQD_Zone>
  ...
  <!-- Predecessors can occur several times and thus
  needs a nested feature type.

          But the attribute aqd:predecessor is not
  available as an XML-element -->

    <aqd:predecessor
  xlink:href="AT.0008.20.AQ/ZON_AT_03" />

</aqd:AQD_Zone>

```

Fig. 5. Nested feature type with non-trivial mapping

We solved this by providing private schemas which construct elements from the needed complex types which are not exposed to the outside.

- Sometimes it is possible to provide attributes to the top level element of a mapping (the “target type”). App-schema refuses to modify the top level part of a target type thus making certain mappings impossible.

- Due to INSPIRE each feature must be furnished with a version ID. The exact form of this ID is not specified. Especially there is no way to find the newest report without knowledge of the exact composition of the version ID.

This means, that without extra knowledge of the system a client is not able to filter the reports of a special year or even the “current” report.

For this reason we will currently only publish the newest reports although the database behind will store all versions.

V. SOS, OPEN ISSUES

- The SOS specifications [7] describe an optional call “GetObservationById”. The intention is to retrieve the same data again at a later time. The term “the same data” can be read as “the data that are selected by the same set of filters” or “the data that have been the current data when the ID was initially provided”, whereby based on the specification of the SOS standard, the second interpretation seems more likely. The INSPIRE data specifications make the implementation of this call mandatory as a way of linking measurement data to an environmental monitoring facility. This in turn requires being able to access data via an ID; the reporting use requires that the data are re-provided as they were, when the report pertaining to this data was created.

Unfortunately, there is no mechanism within the SOS API through which the user can specify for which requests (getObservation) the results must be persisted for later retrieval (GetObservationById). As the source database used (UWEDAT) does not support versioning, previous requests

cannot be re-queried, and thus the results of all requests must be stored in full. While a sophisticated storage method might reduce storage requirements, the data volume generated through the storage of all responses over time will become an issue for any server.

To mitigate this issue we propose a minor modification to the SOS protocol, allowing the user to specify if the result of an request is to be stored, and for what time period. The default setting should be no storage. Such a mechanism would allow the user to decide if the response should be stored, thus reducing the burden for storage on the SOS server.

- Difficulties were also encountered in the process of implementing the SOS server for AQD e-Reporting data as pertains to the current structure of the Offerings-Section of the SOS’ GetCapabilities-response. A natural way to group observed properties in the Offerings-Section of the SOS’ GetCapabilities-response is by station, with the offering providing metadata on all measurement data (observed Property) available from the station, and thus allowing the user to request data for multiple properties within one getObservation request. A further problem is posed by stations that measure the same observable property more than once, as happens in cases when the same property is measured by different devices to compare the results of the different methodologies.

However, this is proving impossible using the new offering structure from SOS version 2.0, which only allows such grouping in the case that the same methodology is used for the assessment of all properties provided. Thus, an explicit offering must be provided for each triple of observedProperty, procedure and featureOfInterest. While this provides the most semantically sound description of the available data, it creates a plethora of offering entries, making the GetCapabilities-response exceptionally long and difficult to interpret. In addition, it reduces the flexibility which data can be queried within one getObservation request.

VI. OUTLOOK

The SOS used in this solution is a new implementation based on the openUwedat-Framework developed by AIT [1]. This framework provides a harmonized way to wrap virtually any source for time series data by adapting the data handler class as documented. The use of such a data handler as the interface to the data source allows for adaptation of the SOS to many existing systems. Writing a data handler is something that can be done by a system integrator other than AIT, as the integrator must only implement a predefined interface in java. This is supported by a set of existing helper classes. Given the end user organisation has java developers at hand this can also be done by the end user without external support.

Note that data handlers do not necessarily need to interface a database in the classical sense. Other interfaces, like that used by the EAA, are also possible.

The openUwedat system makes no a priori assumptions about the composition of the measurement data. This allows

for the provision of auxiliary data like quality information together with the core measurement data. OpenUwedat's ability to handle semantic information related to each time series [2] makes it possible to control the fields that are included in the SOS output.

The SOS does not provide measurement metadata directly but depends on WFS as a companion service, accessing the requested measurement metadata from this service and re-formatting the data as required for re-provision under SOS. The way we have designed the AQD database underlying the GeoServer with a structure closely linked to the output formats makes it possible to reuse the same configuration within different administrative contexts. It is also possible to adapt the both the GeoServer configuration as well as the openUwedat based SOS for the provision of other environmental media outside the domain of air quality.

Therefore we look forward to and encourage not only the INSPIRE community to experiment with the AIT SOS solution and to adapt it for other environmental monitoring domains as required.

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Towards an air pollution health study data management system - A case study from a smoky Swiss railway

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Abstract—In air pollution health studies, measurements are conducted intensively but only periodically at numerous locations in a variety of environments (indoors, outdoors, personal). Often a variety of instruments are used to measure various pollutants ranging from gases (eg, CO, NO₂, O₃, VOCs, PAHs) to particulate matter (eg, particles smaller than 2.5µm: PM_{2.5}, PM₁₀, ultrafine particles: UFP), and including other environmental parameters such as temperature, relative humidity, GPS position. As a result it is always a significant challenge for researchers to effectively QA/QC, combine, and archive these data so as to reliably assess people's exposure to poor air quality. With the CEDAR system presented here we aim to provide a solution to this problem by employing a platform using templates for easily reading custom formatted files, apply rules for filtering and quality checking measurements, and ultimately publishing them as services on the web. The system is demonstrated for the case an air quality project conducted in a Swiss railway station where smoking is allowed.

I. Introduction

Environmental data collection and analysis are an integral part of many scientific pursuits. Environmental data management tasks exhibit extreme variation for several reasons. The nature of each project or study significantly impacts the data management techniques employed (if any at all). Each discipline has its own preferred methods, including nomenclature and standards. Many details are domain-specific, hence well known, and several decisions are ad-hoc. Last but not least, the scope of each project is typically limited to the problem at hand, which narrows down the intended scope of data management tasks to the very immediate and short-term actions. As a result, there are few tools available for efficient environmental data management, curation and sharing.

In this paper, we present our developments towards a system that efficiently manages sensor-borne data, called CEDAR. CEDAR (stands for Customizable Environmental Data Archive) aims to be domain-independent and customizable, so that it accommodates the needs of different domains and studies, while at the same time provides simple templates for common sensor and data management tasks. CEDAR focuses on time series operations, as they are integral to sensor-borne data. The CEDAR platform is designed so that sensor and data semantics are explicitly declared, along with processes accounting for the nature of different measurements.

Built on top of rich semantics, CEDAR is capable of providing standardized services, for data archival, curation and sharing. Mechanisms for intra- and inter-unit operations are set in place, to respond to user-defined queries. There are also features for common tasks, such as extracting derivative quantities, performing quality checks (QC) and quality assurance (QA) tasks.

From an architectural point of view, CEDAR is built on templates, so that general solutions can be re-applied easily and dynamically, i.e. without the need to recompile the software or append the database. Our assumption is that sensor data sets become available in custom file formats, which are stored by the system “as is”. Each sensor output file is accompanied with template files, which enable CEDAR to not only read the data, but also to *understand it*, from its semantic metadata. Templates contain instructions on how to parse the data as well as annotations of the observed quantities and phenomena. In this way, data sets are stored as measurements of certain phenomena in the common database, and extra functions are enabled for quality checking, extracting derivative quantities, and summaries. These are also enabled through templates. Last, but not least, environmental datasets are offered on the web as services, which allow for end user applications to query and retrieve them through a graphical user interface (GUI).

In this paper, we outline the CEDAR framework and present its design and implementation. Our first experimentations with real world data to demonstrate the system operation are in the domain of air pollution health studies. The main driver for this choice is the variety of pollutant monitoring equipment employed in such studies. In this paper, we present our experiences with managing data from a study of a Swiss railway station, where smoking is still allowed. Scientists collected data using both fixed stations and moveable equipment. The variety of data is being assembled via templates into an archive and presents the challenges of working with such data and what the next steps in this process could be.

II. Related Work

In environmental sciences, sensors are tools that produce measurements, which serve as ground truth observations for subsequent studies. In principle, sensors can be of several kinds, each

addressing different needs and concerns, and, correspondingly, their output can also vary. Combining many of them for a single study, and analyzing the collected information in an organized manner often poses a new challenge: not of discipline or of science, but merely one of appropriate management. Effective management is a prerequisite for certain aspects of data analysis [1].

The aggregation and collective processing of many heterogeneous datasets, which nevertheless refer to the same core physical quantities for the same purpose, are very challenging to implement. An approach in which semantic annotations are not only directly tied with the actual data, but also considered for every operation, can circumvent these challenges and lay the groundwork for a unified and semantically-aware management system [2], [3]. Lee *et al.* [4] delve further into these challenges and present the Concinnity platform to address concerns about trustworthiness.

Software tools as EQuIS [5] and TerraBase [6] software, provide a wide range of operations. Both accept datasets, subject them to arduous QA/QC processes, and store them in their respective underlying databases. The database management systems are also complemented with data visualization modules, with specific emphasis on geological parameters.

A. Air pollution health studies data

In air pollution health studies, measurements are conducted intensively but only periodically at numerous locations in a variety of environments (indoors, outdoors, personal). Often a variety of instruments is used to measure various pollutants, ranging from gases (e.g., CO, NO₂, O₃, VOCs, PAHs) to particulate matter (e.g., particles smaller than 2.5µm: PM_{2.5}, PM₁₀, ultra-fine particles: UFP), and including other environmental parameters such as temperature, relative humidity, GPS position. As a result, it is always a significant challenge for researchers to effectively QA/QC, combine, and archive these data so as to reliably assess people's exposure to poor air quality. Now, with the advent of cheap real-time sensors and the growing internet of things, there is an increasing need for well-designed approaches to archiving these data, so that they can be flexibly accessed with ease by researchers as well as the general public.

In our demonstrator, we deployed our framework for the case study of an air quality project conducted in a Swiss railway station where smoking is permitted. The pollutants monitored were PM_{2.5}, UFP, black carbon, nicotine, temperature, relative humidity (RH). There was one fixed site, and seven other train station micro-environments surveyed by field staff carrying real-time instruments.

B. Time series data management and fusion

Management systems that can adequately process time series data have been in the spotlight of the inter-disciplinary research community. A lot of efforts have been put into developing management systems, specifically designed either for real time

adaptation and processing of time series data, or for archiving them and providing a query service over them.

In GALILEO [7], database implementation is of great importance, because the system is optimized for storing streaming data. In order to cope with node failures, which would lead to data loss, they replicate data storage nodes. Thus, GALILEO needs a lot of computational power to function.

TSMS (Time Series Management System) is a specialized object-oriented Database Management Systems for the banking industry [8]. The system they envisioned should be able to interact with and facilitate the functionality of external programs (e.g. modelling platforms, decision support systems), and apply filters on existing time series. In addition to that, the aforementioned system should cope with data reliably, assigning tags on each measurement.

Mason *et al* [9] introduce the Virtual Observatory and Ecological Informatics System (VOEIS) Data Hub, a centralized data management system which curates environmental observations through data life cycle. Metadata annotate every measurement and templates are utilized for the data input process. While templating facilitates input process, VOEIS software implements it only for specific types of files (csv, xls, xlsx), which renders our input approach more robust and promising.

In AiRCHIVE [10], the authors implemented an autonomous environmental data archival system, which received input from sensors attached to it. While efforts were concentrated on incorporating web protocols which enhance interoperability, little efforts were allocated on input and data storage methods.

Time series data often comes in very high volumes, so using a document-based system like MongoDB is a common solution. User activity monitoring [11], server logs and real system records are all common applications; however, the systems implemented for those tasks rarely need to address needs other than data storage and very elementary operations. In fact, distributed processing techniques are often pursued for the purpose of analysis [12]. Additionally, efforts have been made to resolve such issues not by implementing new management systems, but by developing interfaces for aggregated information retrieval from different source databases [13], [14].

Ghanem *et al* [15] discuss data integration techniques on a grid-based collective system, but ultimately propose the design of different APIs for each specific workflow. They also mention the potential in semantic tagging for such information, reinforcing our belief that our system truly has potential.

C. Terminology

Concerning the vocabulary used in the following sections, and in order to avoid any ambiguity, some terms have to be defined first. A *measurement* refers to a set of values recorded *simultaneously* by a single sensor. The number of values recorded is entirely dependent on the sensor used, but it is at least one.¹ Note the

¹As an example consider a GPS sensor device that yields two or three values: latitude, longitude and altitude (optional).

constraint: each measurement must state its time of collection. Furthermore, each measurement may carry several tags associated with it. A *time series* consists of several measurements, i.e. pairs of time-stamped values. It refers to a single physical quantity observed over a time interval. Time series are regular when measurements are taken at constant time intervals. They may contain missing or erroneous values, as they represent the raw output of the sensor instrument, without other processing.

III. System specifications

The main objective of CEDAR is to provide a means for easier data management and analysis for sensor-borne data. Air quality health studies data comprises numerous measurements, heterogeneous in both meaning and format, as they are collected by different equipment. Our goal is to organize all measurement datasets and make them available via interoperable, queryable services. In the following sections we present the key features of our system.

A. Requirements

A CEDAR project involves the curation, archival and processing of several time series, using one or more sensors, each observing different phenomena. Each sensor produces a custom text file that contains that results of each measurement for a certain period of operation, and all these files are made available to CEDAR.

The first step is to make explicit the semantics of each observation process occurring. This inevitably entails the identification of the physical meaning and unit of the measurements produced by each sensor, which can be associated with other factors of interest (e.g. substance, medium, etc.) or spatiotemporal references. Undoubtedly this depends on the specific needs of each project. Domain scientists need to be involved in this step to make such information available, using the appropriate metadata templates. Templates depend on the type of equipment, as each instrument typically produces its own file format. The system may also extract information from the underlying folder structure, as scientists tend to encode valuable information there, which needs to be extracted and processed. Metadata templates serve as the source of some primary QC statements: minimum and maximum allowed values for each measured quantity can first be stated there, and then used to fix those not complying.

Secondly, CEDAR is able to execute common time series operations. These may occur at predefined time spans (e.g. hourly, weekly, monthly, etc.) or at user-specified ones. The system provides built-in support for the most common operations, such as calculation of maximum, minimum, rolling mean, average and percentile values. Additionally, the user is able to specify more functions via an extension mechanism.

Thirdly, CEDAR combines existing measurements into derivative user-defined quantities, and appropriately tag them. This includes operations across different units (and unit conversions), as well as other transformations. Newly calculated information, based on a user query, can be optionally stored into the archive for future

reference. Such operations include quality test and assurance procedures, which can be done in two stages: Either when data is initially imported into the archive, according to existing rules given by the user, or later by revisiting datasets and expanding them with QA/QC tags.

The system may also offer additional services: missing or suspect measurements are detected and tagged as such, and basic value correction functions (e.g. due to calibration errors or offsets) may also be implemented via templates.

Last, but not least, data archived by CEDAR and most of its capabilities must be offered as services over the web. A RESTful implementation was deemed preferable, to enhance transparency and promote scalability, among other advantages. A GUI was developed in order to provide users with the means to submit queries and visualize data, effortlessly. Data dissemination in a interoperable way, an essential feature for a sensor data management system, was addressed by adopting Sensor Observation Service (SOS). SOS is an Open Geospatial Consortium (OGC) standard, which allows querying observations and sensor metadata, employing a set of predefined and well documented requests.

B. Abstract architectural design

The CEDAR platform operates in four stages, shown in Figure 1. Each input needs to be accompanied by two template files. The input template, and the metadata auxiliary file. They allow the template reader component to successfully identify and tag the information in each input data file. The **template reader** goes through each input data file, and parses its text according to the instructions in the input template. The metadata auxiliary file provides with additional semantics for constructing a timeseries of measurements from the data. It may also provide with additional information and optionally filters suggested to generate derived timeseries or perform common tasks as QA/QC. The semantic auxiliary file may also associate the quantity measured with one or more corresponding ontologies, which subsequently allow for easier collaboration between different people and teams, in compliance with the semantic web vision.

In the second stage, the newly formatted and semantically-tagged time series are imported into the **database**, which constitutes the innermost layer of the application. For reasons explained below, the document-based database MongoDB was deemed suitable for this implementation. At the top level, time series are categorized according to the study they are part of, the sensor that produced them, and optionally by a more sophisticated structure, suitable for each project. CEDAR always preserves the raw data, as initially imported, along with the results of the QA/QC process.

The database component is connected with the **processing layer**. This component intercepts all data from the database, and translates each time series into a set of objects for further processing. It is also here where the more complex operations are executed, as they become significantly easier with the object-oriented structures. The object-oriented application layer can also accept custom user filters and use them in its operations.

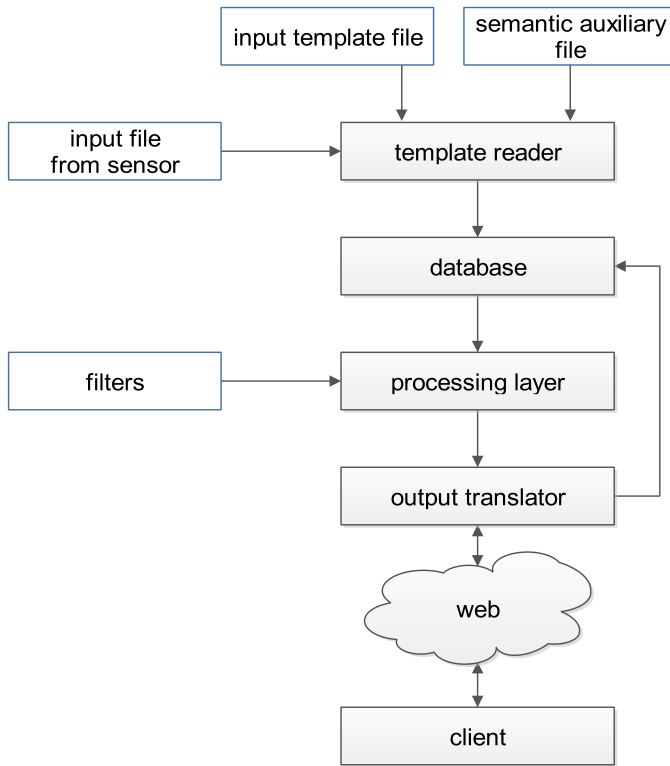


Fig. 1. CEDAR abstract architectural design

The **output layer** is the module in direct contact with the end-user via the web. It accepts custom queries from the graphical user interface, and subsequently translates them in a way the object-oriented layer can interpret. Furthermore, this component is responsible for resolving user queries, as well as for preparing the responses to them.

An additional component is the client interface. An interactive GUI is preferred, as it simplifies the querying process, and is able to present the user with additional features, executed on the browser. These includes on the fly visualizations and transformations.

IV. Detailed design

In this section we provide an in-depth description of each component and its function and implementation details.

A. Template reader

The template reader is the component responsible for the initial extraction and composition of each time series from an input file. As mentioned above, two additional files are necessary for this process. We have developed the template reader from scratch and it was written in Python. The input template file is a text file that mimics the structure of its corresponding input file. Usually these input files consist of a header section, with details pertaining to the entire measurement set, and a table-like section containing the measurements themselves. Both sections can include valuable

data that we want to acquire. It is imperative that the structure of the template file and the input data file be identical, as anything else would result in complications. This includes whitespace, tabs or other non-visible characters, which is very important for the detection of irregularities (in particular, missing values). The template reader is able to handle any text file as input, ranging from the easily-parsable CSV files, to the less strictly-formatted text files. Our current implementation uses regular expressions, which are derived from the template file.

We sought a simple way to compose input templates, and concluded that a pattern similar to popular output template libraries as Cheetah [16], or Mako [17] would be sufficient. In these, constant text is simply represented as such, and variables follow a specific pattern. Mimicking that, we use the \$ identifier to mark variables, followed by the variable name surrounded in curly brackets{ }. The result of this format is of the type: \${variable_name}.

Variables may be found in both header and tabular sections. Typically in headers we have some kind of simple key-value assignments of values to variables. Some of them could be optional. In the tabular section we need more constructs to fully describe the content, as we need to associate values with references (temporal or spatial coordinates) and possibly an unknown number of occurrences.

To signify that a set of rows should be processed according to a common template line we introduce the <%title> tag, inserted into the line before the template line in question. The line following the <%title> becomes the common pattern, and is used for all lines following the subsequent <%process> tag. These tags are always expected to appear together, and mark a tabular portion of a file.

An assumption made should be noted here: we expect that each measurement is fully contained in a single line, and that each one of them includes a time stamp. Template files ignore consecutive whitespace characters, as these can be inserted by various sensors liberally to enhance the readability of their output files. Unfortunately, this also implies that spaces cannot be reliably used as delimiters in the measurement section, as missing measurement values would complicate the proper parsing of a file.

This way, given one piece of an input file, we can effortlessly create a fitting template by only editing it, and thus specifying the variables we wish to be read by the framework, as shown in the code segments below.

Code Segment 1: Example input file. Note that (·) stands for a single space and (→) signifies the tab character.

```

Filename:·4A14Q401.TXT
Averaging·Period:·1·sec
Date·and·Time:·2015.02.03·09:30:00
Offsets:···0.23→···0.41

```

```

Time→Batt→Temp
0→·8.32→17.7
1→·8.32→17.5

```

Code Segment 2: Corresponding input template. A template file is expected to be found with the `.tmpl` file extension.

```
Filename:·${filename}.TXT
Averaging·Period:·${avPer}·sec
Date·and·Time:·${datestamp}·${timestamp}
Offsets:··${offset1}→··${offset1}
```

```
<%title>
${Time}→${Batt}→${Temp}
<%process>
```

The metadata auxiliary file contains all relevant semantic meta-information for each sensor type. Each variable defined in the input template has a dedicated section here, which includes all metadata and tags that need to be indexed and archived in the database. Semantic awareness relies on these files, so this is a very crucial component. Most commonly, each variable declares its physical quantity, units, spatiotemporal reference and custom properties may be added as necessary. A short example follows:

```
timestamp:
  quantity: time
  units: hours:minutes:seconds
  format: HH:MM:SS
Time:
  physical quantity: offset
  units: second
Temp:
  quantity: temperature
  units: Celsius
  medium: Ambient Air
  sml-identifier-shortName: DHT22
  sml-identifier-sensorID: AnalogTempSensor
```

Names are case-sensitive, and variable names should always be unique in each template. As mentioned earlier, all variables are expected to have the first two fields, namely `quantity` and `units`. Other predefined fields, such as `format`, can be used to indicate the format of the variable to be read. Furthermore, a user can define own fields (e.g. `medium`) to specify more properties to be indexed for that variable, which are subsequently available to the processing layer. The metadata auxiliary file is formatted as a common `.yaml` file [18].

B. Database

The database selected for this project is the NoSQL document-oriented database MongoDB [19]. As opposed to its traditional relational counterparts, a document database presents the following redeeming features for our given scenario:

1. More efficient and easier handling and management of the potentially huge “tables” which hold the set of each kind of measurements, as regards table sparsity.
2. No obligation of adherence to a predefined database schema; increased adaptability to new formats of sensor inputs, domains of application, etc.
3. Excellent horizontal scalability (scaling out), as project datasets (or even different time series, on a lower level) are split and saved as separate documents.

4. Connected information, such as elements of the same time series and their direct derivatives (e.g. averages), can all be easily retrieved from the storage in relatively contiguous read operations, as documents display less fragmentation.

The above is directly derived from the nature of document-based databases: as the name implies, their elementary storage and basic structural units are documents, which directly correspond to files. Each of them can follow a different schema, and allows for further nested documents inside it, as well as references to other documents. Document size is generally on the scale of a few megabytes up to a maximum of 16MB, which is appropriate for even exceedingly long time series data.

In our case, each time series is stored in a single document. Splitting a set of measurements with numerous variables into as many independent time series provides certain benefits: document size can be kept to a minimum, and queries requesting information about a single variable need not be subject to the overhead involved in reading all data collected in that specific session from the sensor. It is also desirable to avoid over-fragmentation of data in many document files, so it is conceivable that homogenous measurements from consecutive measurement sessions –potentially recorded from the sensor into separate input files– can all be included in the same document. Another benefit of splitting the data into individual time series is the possibility of incorporating more data, in the form of e.g. tags for each measurement as a result of a user query, into the same file more easily.

Semantic fields and tags, as drawn from the semantic information file in the templating stage, are common to all associated measurements, and are placed at the root of the document. The measurements themselves is structured in the way described below, similar to the technique seen at [20]. Date and time is expressed by means of nested documents at varying depths, and creating in this way multiple sub-documents. Year information is placed at the top of the hierarchy, followed by month and then day in their respective subdocuments. At this point we can also separate each day into hours or even minutes or seconds, depending on the granularity of the data provided. A side advantage of this is also found in keeping subdocument volumes low. The lowermost level of the hierarchy consists of key-value pairs; time information is expressed in the former, while the latter is another document containing all the information associated with a single measurement. This includes the actual values measured at that specific point in time, as well as custom tags as provided by the user or calculated by the system.

This way of separating date and time information into successive subdocuments benefits the type of operations we would like to perform on each time series. Calculations of quantities such as averages, maxima and minima can be easily executed, stored and retrieved for each of the subdivisions. Other valuable information, such as the number of measurements with specific tags over easily defined time periods (e.g. over a month) can also be explicitly stored at a corresponding document depth.

C. Processing layer

This layer consists of two sub-components associated with core data processing operations. The first sub-component connects to the database and creates measurement objects. The second is able to apply operations on those objects by applying filters (operations) in order to generate derived measurements or other results. In the processing layer, each object represents a measurement, or a set of measurements combined in a meaningful manner. Variables store the IDs of each element of a measurement, their corresponding time stamps, units, and other tags. The output layer reads each part of a user's query, and determines which time series should be read from the database. Each element of that time series is transformed into an object holding all of its data, and these objects are then assembled into one primary time series object. The time series object also draws from the database any information pertaining to all objects-elements it encloses, which are at the very least annotations for the physical meaning of their values as well as their units. Furthermore, the same time series object is instructed to mark the methods that will produce from it a secondary time series object with all necessary properties and values, as a step towards answering the user's query. Finally, one or more time series objects are passed to the output layer, as they contain the final response information.

D. Output layer

The output layer acts as the front end of the system to the outer world. It receives queries from the web, either from end users via the GUI or from other machines via REST-full protocols, and responds to them appropriately by calling the appropriate objects and activate filters in the processing layer. As regards the output, this component simply transforms the objects produced in the processing layer into the appropriate format. This can range from simple serialization into text (e.g. XML, JSON, YAML formats) to commands that would insert the information contained in the objects and queried for by the user back into the database itself for future use. Output templates can also be used at this stage, so the results of processing can be presented to the user in the form desired. The templating engine Mako [17] was used in this project for this purpose. In order for this feature to work, the output translator must also be able to connect the variable names inside a template file with their associated query results, since these engines generally function with text substitution.

Following the submission of a user query to the system, the input translator's first task is to formulate a query toward the database and then pass it to the object-oriented layer, where it will eventually be submitted to the database. Simple queries, such as the presentation of all measurements in a time series, only involve a direct request to the database and appropriate formatting of the data returned. More complex ones would necessitate more object structures and potentially more queries to the database, so all relevant information can be retrieved. The most important operation of this translator lies in defining these object structures as would best suit the given task, the relationships between these structures, and queries to draw their data from the database.

Among the data structures provided there has to be one that will suit the result. Especially considering that this result might be stored back into the database, regardless of what the output presentation to the user entails, the resulting object has to contain all data necessary to uniquely identify its sources and be stored with references to them, if not enclosed in its parent time series. Finally, it also provides the logic to answer a user's query, expressed in terms of the objects that the object-oriented layer will construct under the guidance of the input translator.

E. Client interface

This component is responsible for presenting the user with a practical graphical interface, and transmitting the choices made by the user to the server hosting the service. The GUI draws from the database information concerning:

- available physical quantities, as expressed in the semantic information file
- tags accompanying these physical quantities
- sensor information
- available time information.

With the above the user can select their desired inputs, apply filters among a collection of predefined and user-defined ones, and specify the desired output format. Time granularity is also an important parameter which can affect the presentation of the output.

Inputs can be processed individually, i.e. depend on a single physical quantity time series to produce the output. For instance, this would be the case for an averaging operation. More inputs can be combined for more complex processing, where accounting for more variables over certain time periods is preferable.

F. Sensor Observation Service interface

SOS component is currently under development, but when available, it will provides an interface to make CEDAR's sensors and sensor data archives, accessible via an interoperable web based interface. *Core* profile, which is defined in the SOS specification offers three operations. The corresponding *requests* to these operations are:

- **GetCapabilities**, responds with a self-description of the service. It includes detailed information regarding the hosted data and the available operations.
- **DescribeSensor**, responds with metadata about the requested sensors and sensor systems (procedure key).
- **GetObservation**, responds with measurements of a selected quantity (**ObservedProperty** key), measured by a specific sensor (procedure key) at a specific time (**eventTime** key), in a requested response format (**responseFormat** key).

V. Implementation

A. Case study

Since May 1st 2010, Switzerland has had a federal law against environmental tobacco smoke (ETS) in enclosed spaces that are publicly accessible or where workers are present; however, smoking is allowed in separate smoking rooms, open spaces and in private homes. In terms of public spaces, there has been much controversy around smoking in hospitality venues: e.g., restaurants, cafes, bars, but minimal discussion about smoking in quasi indoor public environments such as train stations with the exception of several newspaper articles about ETS in Zürich's main station during Oktoberfest (www.tagesanzeiger.ch, 2014). Switzerland has the densest train network in Europe and railway travel is the main mode of transportation in Switzerland with Zurich, Bern, and Basel having >400'000, >200'000, and >100'000 passengers per day, respectively. However, despite general public reliance on this travel mode, smoking in train stations is hardly restricted. [21]

In the interest of assessing if the air quality in a Swiss train station presented a potential public health concern, we conducted a pilot measurements study in Basel's SBB main train station in the Fall of 2014 [22]. The pilot consisted of taking measurements with a backpack of direct-reading instruments from mid-afternoon to early evening. The team made four circuits/loops around the train station stopping at 7 pre-selected locations where 6-minute measurements were made (~1 hour/circuit). Another team operated a reference site at one location on the Passerelle (main elevated area of the station where most shops, food stalls, and restaurants are located with access to nearly all tracks). Additionally, nicotine measurements at each of the 7 locations were made in the 4-day period leading up to and including the afternoon of sampling. The pollutants measured were particulate matter of size 2.5µm and less (PM_{2.5}), ultrafine particles (UFP, between 10 and 300nm), and black carbon (BC) all at one second resolution. The PM_{2.5} mass measurement represents the finer fraction of particles that can penetrate to the deeper airways of the lung; UFP particles measured in number of particles per cubic centimeter are sub-micrometer particles that are almost entirely generated by combustion processes; and black carbon is an indication of the darkness of the aerosol and, in the ambient environment, is often indicative of diesel sources. At the reference site, in addition to UFP, BC, two aerosol size spectrometers for the nanometer and micrometer ranges were deployed [22].

The main measurements from the circuits provided data for 7 distinct locations from one set of instruments. This affordable approach, however, results in each location being only characterized for short periods of time and non-simultaneously. Nevertheless, the patterns between locations were consistently similar from one circuit/loop to the next. The reference site provided a continuous picture of the temporal evolution of pollutant levels at one location. Reliable data management and fusion is critical for the effective analysis of these data.

Devices used in these types of measurements are not integrated

into one data-logging system. Instead, each device has its own output file, some of which need to be post-processed using proprietary software, where, e.g., a calibration is applied. The format of these data is expectedly heterogeneous (headers, date/time stamps, measurement units); furthermore, depending on the device and the aerosol sampled, researchers may apply an additional correction factor. Other integrated data (non-real-time data such as multi-day passive nicotine samplers) that only provide a single average for their sampling period need to also be included. These data will be compared to World Health Organization's (WHO) 24-hr air quality guidelines as well as to other ETS studies.

This case study provides one example of the complexity of air pollution exposure science monitoring data. For other studies, with different study designs, such data can be collected in patently different ways and over much longer time periods. A methodology that can flexibly accommodate data is increasingly important as data generation explodes with technological developments.

B. Deployment

CEDAR components were designed to function not only for the purposes of this specific project, but be generally applicable for a wider scope of work. To demonstrate this case study we created templates for reading and annotating the different kinds of sensors involved in this study. The input template is read first by CEDAR, and regular expressions are formed based on it. Comparing each line of the data file with a regular expression isolates the variable values, which can then be treated as regular strings. At the same time, the metadata auxiliary file specifies the semantics of these variables, which can be converted and processed accordingly in CEDAR. Time and date information in the measurement section is tagged as such in the yaml file along with its format, and is combined to form the time stamp for all elements of that measurement. Measurements are all recomposed into their respective time series, marking missing values as such with a tag, and incorporating the header variables at the top level of each time series.

Simple operation to be applied without any further user action can easily be incorporated in a filter file. These filters should be one-to-one relationships, i.e. simple checks for each element of a time series, and are especially useful for selective initial tagging. Example uses include annotation of out-of-limits values and warning labels that would contribute to easier understanding of the data. These filters are only read during the input stage, and actually applied after all data has been imported into the database. They are therefore treated as user queries and executed automatically. The database component is fairly straightforward, as MongoDB document structure can be fully replicated with Python dictionaries, which can be accepted without further processing.

The remaining components are simpler to approach in a backwards fashion, starting with the graphical user interface. A complex user request is broken down by the user into its elementary parts. This not only aids readability, but is also directly translatable into object terms. Each part is given a label by the user, and can be referred

to by other parts of the query. For example, consider a sample query as: “For every hour check if the average concentration of substance A exceeds value X, and the average particle size of substance A was less than Y, then return the two quantities”. This can be broken down as follows:

```
- label: substance_average
  quantity: concentration
  tags: [substance: A, sensor: S], units: #/m3
  filter: average, averaging_span: 1 hour
  time_frame: start_date to end_date
  store_in_database: true

- label: average_check
  filter: condition
  expression: substance_average > A
  store_in_database: false

- label: size_avg
  quantity: size
  tags: [substance: A, sensor: S], units: nm
  filter: average, averaging span: 1 hour
  time_frame: same_as substance_average
  store_in_database: true

- label: size_check
  filter: condition
  expression: size_avg < Y
  store in database: false

- output: substance_average, size_avg
  output condition: average_check AND size_check
  output tags: [alert]
  output format: json
  store in database : false
```

This query would ultimately yield two partial time series as its result, with time stamps accompanying the value averages fulfilling the given conditions. The timestamp storing technique described earlier is a good way to improve the efficiency of time frame lookups, which is a conceivably common operation for time series.

The graphical over-the-web user interface is presented to the user incrementally, depending on their choices. A label, for which a field is always present in each input panel, is given to each quantity, so that the users can refer to them in other sections of the same query. Once a label has been filled in, a dropdown list prompts the user to select the physical quantity of the subject time series. The list is retrieved from the database. A filter and required tags, as well as unit conversions, can then be selected for that physical quantity, with valid options presented again in a list. Parameters to each filter are also defined here, as well as time constraints or granularity for the time series, when applicable. Finally, the user has to confirm the output time series and condition as well as the preferred output format in the output panel.

A query can be broken down into as many sections as necessary. Each of them conveys a simple transformation, and they collectively build a request of arbitrary complexity. The graphical user interface is presented incrementally to the user depending on

their previous choices, and facilitates the definition of each query section by presenting all available options at each step, as well as prohibiting entry of non-applicable filters and transformations (e.g., requesting an average of a status code time series would not be allowed). This process involves communication with the database at various stages, but provides the user with a simple, robust, and easy to use query builder. Results can also be imported back into the database, as suggested by the “store in database” field for future reference.

Each field of this query is transmitted over the net to the server with an HTTP GET request. The input-output translator produces the queries that retrieve from the database the elementary quantities, i.e. concentration and size for this particular case. Time series objects are built from each, carrying all relevant information. However, they also contain the query information to transform them as required. In this case, the object that holds the concentration time series also includes the average filter, with its parameters as set by the user, the units, and the *store in database* value. A concept for this particular example can be seen on Figure 2.

These objects undergo the transformations now specified by their internal parameters, and continue through the instructions the input translator has provided. Semantic information is never discarded. Finally, two objects are returned to the translator, which now formats them and outputs them in two channels. First, a json file is provided to the user as the output format suggests, and secondly the two time series are stored back into the database. If they are results of simple processing, they can be stored in the same document as their original time series. Simple processing is indicated by common origin of the tags and semantic information for all measurements in the time series. Otherwise, separate documents are formed, and all relevant tags are carried over.

This type of querying covers a very wide range of operations. Users can define custom filters as they wish, adhering to specific limitations, to provide additional functions. A filter is provided as Python code and is placed in the appropriate folder. Built-in filters are present in three relationship variations: one-to-one, one-to-many, many-to-one.

- A filter expressing a one-to-one relationship is the numerical transformation filter, which implements simple arithmetic on the given quantities, e.g. temperature + 273.
- A filter expressing a one-to-many relationship is the interpolation filter, which could be used to increase the granularity of a time-wise sparse series.
- Finally, a filter expressing a many-to-one relationship is the averaging filter, which derives a single value from many more.

Currently present filters range in their function from filters offering simple numerical operations and logic checks, to filters that calculate minimum and maximum values, averages, and rolling means.

As far as quality checks are concerned, CEDAR provides some elementary functionality. The first stage of quality controlling

The screenshot shows the CEDAR Graphical User Interface with a navigation bar at the top containing 'Home', 'About', 'SensorObservationService', 'GraphicalUserInterface' (selected), and 'Maps'. Below the navigation bar, there are five rows of configuration options for data queries. Each row contains four columns of input fields and buttons.

Column 1: Quantity/Condition/Units	Column 2: Time/Granularity/Tags	Column 3: Time/Granularity/Save	Column 4: Granularity/Check/Buttons
concentration average #/m^3	2014-05-09 14:40:00 1h substance:A, sensor:S	2014-05-09 19:40:00 Not in use <input checked="" type="checkbox"/> Save	granularity substance_average Add more... Get graph
Select quantity condition units	 substance_average > A tags	 Not in use <input type="checkbox"/> Save	granularity average_check Add more... Get graph
size average nm	2014-05-09 14:40:00 1h substance:A, sensor:S	2014-05-09 19:40:00 Not in use <input checked="" type="checkbox"/> Save	granularity size_avg Add more... Get graph
Select quantity condition units	 size_avg < Y tags	 Not in use <input type="checkbox"/> Save	granularity size_check Add more... Get graph
Select quantity condition units	 average_check AND size tags	 Not in use <input type="checkbox"/> Save	granularity output name Add more... Get graph

Fig. 2. Screenshot of the GUI

consists of basic comparisons against the higher and lower limits provided along with the metadata for each value. Missing values are explicitly tagged as such, but never removed from the database. This also represents CEDAR's general philosophy: in cases where new values are calculated to provide a quality-checked replacement for their old counterparts, those remain in the database, tagged as such. Information loss and one-way transforms are thus discouraged.

In this particular study, no measures were developed to account for the time drifting of sensors. In some cases the sensors are automatically or manually re-calibrated, but these processes are not reflected in the datasets provided to CEDAR. Beyond that, overly long sessions of data-logging were avoided in this instance, so any residual effects of time drifting are considered to be negligible. The system —partly owing to the range of its desirable flexibility— has no way of countering false semantics. We are operating under the assumption such issues this can be mitigated on the end users' side, by careful metadata input.

VI. Discussion and Future work

CEDAR software platform was motivated by AiRCHIVE's initiative [10], resulting to a more mature implementation and a fresh system design. CEDAR counts as a sensor data management system, which can take input from any file, utilizing a sophisticated template engine. On the other hand, AiRCHIVE serves real-time data publisher incorporated in a sensor system. Also,

the document-based Mongo DB, used in CEDAR, facilitates a lot of complex operations on data, unlike AiRCHIVE's relational database which lacks of flexibility.

Although still under development, this system's potential is significant. The case study with air quality monitoring data from a smoky Swiss railway is a solid test to validate the system's functionality. We aspire to evaluate it against different case studies, involving meteorological and hydrological time series data. We also aim to develop more variant built-in filters, which users could apply on data, without developing them. Finally, the backend performance optimization is of great importance to us, so it would respond to queries and operate robustly and time- and energy-efficiently.

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Interoperability and Sharing of Biodiversity Data on a National Network in Italy

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Abstract—Biodiversity protection requires to access and to process many sources of information. The Italian Ministry of Environment has entrusted ISPRA (Italian Institute for Environmental Protection and Research) to manage a program aimed to support interoperability and harmonization of the information stored in different data bases. Some aspects of such program, including the National Network for Biodiversity (NNB), are highlighted and commented, with reference also to other relevant initiatives. NNB has already been implemented, relying also on relevant systems as EC-CHM and EUNIS. However, the current availability of interoperability standards (as for biodiversity related themes in the Annexes of INSPIRE) require to update NNB, also taking into account the global development of the ITC architecture of the public sector.

Keywords—clearinghouse mechanism; heterogeneous data bases; interoperability; biodiversity data and networks

I. INTRODUCTION

Collecting data, processing information and sharing knowledge are essential features of any program meant to ensure the sustainability of the environment by co-ordinated actions of citizens, business entities and public administrations. The availability of network infrastructures and protocols allows to implement the sensible approach based on leaving the data where they are produced and supporting the users to access them whenever they are. However, such approach requires a thoroughly planned effort in order to overcome the barriers that prevent or slow down the circulation of data.

As shown *inter alia* by the implementation of the INSPIRE Directive [1] (whose related initiatives are among the more important ones aiming to cross-link disconnected silos of data), such barriers are cultural, organizational and technological at the same time. On the other hand, supporting changes of cultural legacies, of organizational frameworks and of operational tools is the main mission of ICT. This is specifically true in the domain of the environment-related activities, where huge progresses have been made since the Seventies of the past century: the availability of remotely sensed imagery, of telematic networks and of large data bases have supported new approaches of studying and managing the territorial processes.

Such new approaches include the distribution of digitized data and metadata about the collections of physical items of environmental interest, as those hosted in archives and museums. Similarly to what was happening in other analogous sectors (e.g. the libraries, storing paper documents as books or maps), the user community has felt it necessary to efficiently find information about such collections even if remotely located or also without the need of prior knowledge of such locations.

On such basis, many activities have been carried out at regional as well as national levels. In Italy, the relevant initiatives have to harmonize within the context set by the architectural choices made for the global ITC infrastructures.

II. THE ITALIAN PROGRAMME FOR BIODIVERSITY

ISPRA (the Italian Institute for Environmental Protection and Research) cooperates with the European Environment Agency (EEA), in its capacity of being the Italian national focal point of the EIONET network and also a member of both the European Topic Centre for Biodiversity Diversity (ETC/BD) and the European Topic Centre for Spatial information and Analysis (ETC/SIA).

The Institute (www.isprambiente.it) acts under the vigilance and policy guidance of the Italian Ministry for the Environment and the Protection of Land and Sea (Ministero dell'Ambiente e della Tutela del Territorio e del Mare - MATTM). ISPRA carries out (involving partners from academia, industry and public administration as necessary) its programs on the basis of national laws and of international obligations (e.g. the Copernicus program establishing a European capacity for Earth Observation).

ISPRA has been entrusted with the management of a program aimed to improve information access and sharing in the biodiversity community. Such information is stored in different heterogeneous data bases, therefore technical and organizational problems have to be dealt with. The related initiatives have been carried out with a strong involvement of the relevant stakeholders, as a means to reach their goals in an effective way. The technical solutions have been based upon applicable experiences in Italy, Europe and abroad.

A. The National Strategy for Biodiversity (NSB)

As an obligation derived from art. 6 of the Convention on Biological Diversity (www.cbd.int), MATTM has established the National Strategy for Biodiversity (NSB) [2], in cooperation with other stakeholders (ministries, regional authorities, citizens etc.) and taking into account the relevant EU Directives. Such Strategy (currently spanning from 2010 up to 2020) focuses on three main themes: biodiversity and ecosystem services, biodiversity and climate change, biodiversity and economic policies.

To implement the Strategy, three strategic objectives (all of them implying an effective information sharing) have been identified:

1. “By 2020, ensure the conservation of biodiversity, or the variety of living organisms, their genetic diversity and the ecological complexes of which they are part, end ensure the protection and restoration of ecosystem services in order to guarantee their key role for life on Earth and human well-being”;
2. “By 2020, substantially reduce the nationwide impact of climate change on biodiversity, by defining the appropriate measures to adapt to climate changes and mitigate their effects and increasing the resilience of natural and semi-natural ecosystems and habitats”;
3. “By 2020, integrate biodiversity conservation into economic and sectoral policies, also as potential for new employment opportunities and social development, while improving the understanding of the benefits from ecosystem services derived from biodiversity and the awareness of the costs of losing them”.

The implementation of NSB has been harmonized with the indications of the EU biodiversity strategy to 2020 [3].

B. The “Sistema Ambiente 2010” project

The preparatory studies of NSB pinpointed that the biodiversity information was scattered in a number of heterogeneous data base, making its exploitation difficult or even unreliable. Therefore, MATTM has financed the “Sistema Ambiente 2010” project, aimed to find a technical and organization solution to manage the biodiversity data in a way to meet the needs of NSB.

C. The National Network for Biodiversity (NNB)

In the framework of “Sistema Ambiente 2010”, ISPRA has implemented the National Network for Biodiversity (NNB) in 2012 [4]; afterwards, ISPRA is committed to maintain and to improve NNB, in order to extend the number of connected organizations in the biodiversity domain. NNB is meant to support the collection, validation and re-use of the thematic knowledge.

NNB, together with the dedicated “Portale NaturaItalia” web portal (www.naturaitalia.it), provides the services of the Clearinghouse Mechanism (CHM) for Biodiversity, fulfilling

the role of Italian node in the system of the CHMs required by the CBD.

From the organizational point of view, a specific technical and scientific committee (CTS) has been entrusted to assess the quality (in terms of accuracy, relevance, completeness and reliability) of the information distributed by the network and to assist all the network entities in reaching and maintaining the necessary quality levels. The CTS members are appointed on the basis of their professional skills and are mainly selected from the academia.

The NNB entities pertain to three classes of users:

1. *Contributors*: this class includes network members providing data on a *ad hoc* basis;
2. *Focal points (FP)*: public bodies, local administrations, museums and research centers that provide data and moreover are able to implement network nodes using their HW/SW infrastructure, in order to support the generic Contributors;
3. *Centers of Excellence (CdE)*: university institutes and research laboratories, with a high level of specific expertise; they are committed to actively manage the scientific content of the network, both cooperating in the assessment of data provided by the network entities and carrying out large programs addressing the data collection and classification.

FPs and CdEs are recognized institutions at national and international levels and provide reliability to the whole network. Contributors, FPs and CdEs are the actual owners of their data and are in charge of their administration. Specifically, NNB in itself support the access and re-use of information, overcoming the heterogeneity of the data sources.

III. TECHNICAL ISSUES

The global requirements for the implementing NNB, as briefly described in the above, include the features of distribution, heterogeneity and autonomy. Such features, as defined in a seminal paper [5], imply ITC solutions based on a federated architecture.

Such ITC solutions support the sharing of information in a collections of loosely coupled data sources, on the basis of an agreed set of rules. Each data source stores its data according to its own specific model (not necessarily structured in a database, as shown in [6]); the set of rules allows to map each specific model to a agreed model, common to all the components of the federation i.e. to all the systems hosting the different data sources.

When a federated system needs to get data from the other systems, it launches its query with reference to the common data model; suitable software tools (a.k.a mediators or brokers) translate such query to the specific models of every data sources as mapped to the common data model; other software tools (a.k.a wrappers) provide the mapping of the specific

models to the common model. Obviously, the more the specific model are similar (i.e. are harmonized to the common model), the less transformation effort is needed.

A more advanced approach extends the set of agreed rules to include the exchange of messages among the federated systems, in order to get more generic services, other than data retrieval [7]. Accordingly, the systems achieve various levels of interoperability, defined by [1] as “the possibility for ... data sets to be combined, and for services to interact, without repetitive manual intervention, in such a way that the result is coherent and the added value of the data sets and services is enhanced”.

Actually, federated systems have been widely exploited in bioinformatics. Generic requirements and possible solutions are provided by [8] and [9]. The federation of data sources and the availability of web services is compared in [10]; accessing non-relational data sources on the web is discussed in [6].

Specific requirements for biodiversity data, with reference to the taxonomic frameworks, have been exposed by [11]. Biodiversity data requirements are linked to the wider domain of bioinformatics; the use of organism names as a universal metadata element connecting biodiversity data from separate data sources is pinpointed in [12].

Arguing about the adoption of taxonomic names as identifiers in federated systems, [13] reviews possible alternate candidates and suggests to rely upon Digital Object Identifiers (DOIs) and Life Science Identifiers (LSIDs); such themes are revised and extended in a more recent review paper [14]. The challenges of the data formats of different sources (e.g. natural history collections, survey reports, scientific literature) to the discovery of global biodiversity patterns and processes (i.e. within a “big data” approach) are discussed in [15].

NNB has been implemented with reference to such context. Specifically, the NNB design has initially been based on the architecture of the biodiversity clearinghouse (EC-CHM) implemented by the European Environment Agency at the end of past century, as an important experience of promoting and facilitating technical cooperation, knowledge sharing and information exchange amongst national CHMs of the EU member states. In order to duly ensure coherence with other systems of MATTM, some components of the technical infrastructure have been modified. Afterwards, BISE - Biodiversity Information System for Europe (biodiversity.europa.eu/chm-network) has been taken into account as the evolution of EC-CHM itself. The general approach has been to provide a similar set of functionalities and, as far as possible, a similar user interface even when the technical tools have been modified (as in the case previously mentioned).

As a federated system, NNB relies on:

- a central node supporting the queries on the accessible data sets;
- common protocols for describing and accessing the shared data.

The central node, on top of the usual functionalities (from user authentication to query routing and load balancing), has been completed by a replica of the EEA’s EUNIS database (eunis.eea.europa.eu/). Such database (built at the beginning of this century) holds non-redundant, integrated information about species, habitats and sites of interest for EU; therefore, it provides a reliable context for the data provided by the entities participating to NNB.

The software infrastructure has been derived mainly by the relevant experiences of GBIF - Global Biodiversity Information Facility (www.gbif.org/). Specifically:

- data are mapped to ABCD (Access to Biological Collection Data) schema;
- BioCASE (Biological Collection Access Service) Provider Software is deployed as a middleware in order to ensure an abstraction layer between the single data source and the network.

The core component of BioCASE Provider Software is PyWrapper that provides a an XML/CGI interface towards an increasing list of data sets with different structures; a client application therefore exchanges messages with this PyWrapper interface (not directly with the targeted data source), on the basis of the rules made available by the BioCASE Protocol.

It should be noted that PyWrapper has been designed to deal only with SQL-compliant data bases; however, the last version, available since January 2015, is able to map data also from Excel spreadsheets (in order to publish data sources of limited extent, usually provided as spreadsheets). Some other similar extensions should be made available in the future, granting the due generality and flexibility to PyWrapper.

BioCASE Protocol can be seen as a (not back-compatible) evolution of the previous DiGIR Protocol; a new TDWG Access Protocol for Information Retrieval (TAPIR) is meant to reconcile both of them. Moreover, also the ABCD schema is evolving: e.g. a version denominated ABCDEFG (ABCD Extended for Geosciences) has been produced, in order to include data also from palaeontological, mineralogical and geological digitalized collection data [16]. The ABCDEFG schema is exploited by GeoCASE (Geosciences Collection Access Service), an extended version of BioCASE.

In NNB, the user interface is provided by a GeoCASE web portal, fully supporting also BioCASE. Moreover, ABCDDNA (a theme specific extension for ABCD) is being adopted to support storage and exchange of data related to DNA collection units.

NNB coordinators can rely upon a dedicated tool, the Monitor Service Biocase [17]. Such tool records the global level of service provided by NNB in terms of active users, volumes of exchanged data, list of involved data sources etc. Moreover, the tool supports the validation and the quality check of the logical mapping of a data source vs. ABCD or ABCDEFG schema.

IV. NNB AND THE PUBLIC ITC INFRASTRUCTURE

NNB has been deployed as an additional system to the already existent ICT infrastructure of the public administration in Italy. Therefore, its operation has to take into account opportunities and constraints deriving by the relationships with the other systems and relevant legal rules.

A. INSPIRE Directive

The three Annexes the INSPIRE Directive [1] list many themes of potential interest for NNB, mainly: “protected sites”, “land cover”, “biogeographical regions”, “environmental monitoring facilities”, “habitats and biotopes”, “land use”, “species distribution”. The relevant Implementing Rules and Technical Guidelines, currently available on inspire.ec.europa.eu/index.cfm/pageid/2, have been mostly released after the start of NNB. This can imply a modification of the federated schema in order to express its content taking into account the INSPIRE data specifications. In general, biodiversity occurrence data do not directly fall into a specific INSPIRE theme; however, the related information relies also to some INSPIRE data themes. At least, the wrapper should take care of reconciling the data sources schemas and the federated one. Moreover, if the biodiversity data sets are described in terms of INSPIRE metadata, their discovery and reuse are facilitated.

It appears to be useful to mention that, in principle, INSPIRE rules have a well delimited horizon (briefly: spatial data sets pertaining to the public sector; data of interest for environment management; data sets of new creation or thoroughly reshaped). However, in practice such horizon includes most entities and data that are managed in a biodiversity-related network as NNB. Therefore, the assessment of compatibility with INSPIRE should not be ignored.

It should also be noted that the interoperability-oriented approach (on which INSPIRE is based) is going to be exported to many other sectors, overcoming the apparent limits of the spatial data sets of interest for the environment. The European Interoperability Framework [18] has been aimed to facilitate the interoperability of services and systems between public administrations, and also between administrations and the citizens and industry. Moreover, the Digital Agenda for Europe [19] states that interoperability is essential to maximizing the social and economic potential of ICT in EU. Currently, the program ISA² [20] has been launched in order to exploit interoperability for modernizing the whole public sector. Such wealth of initiatives will apparently impact on networks as NNB.

B. Data openness and reuse

NNB makes its content reusable under the IODL – Italian Open Data Licence v.2.0.; the license text is available at www.sinanet.isprambiente.it/it/italian-open-data-license-v2.0.

In Italy, data have to be released by the public administration as open data, according to indications of the Code of the Digital Administration [21]. Various licenses can be adopted [22]; among them, IODL allows any content reuse, also for commercial initiatives, as far as the source is acknowledged. When data are of environmental interest, the

access is granted both to allow the involvement of the citizens in the environment protection and to facilitate new economic initiatives. The legal framework originates from the Aarhus Convention [23] and the PSI Directive [24] [25].

Such commitment to the openness and reuse of public sector data is supported by a common ITC architecture: SPC [26]. SPC connects the heterogeneous systems of the public administration making them interoperable through specialized logical gates. The SPC architecture supports also SINAnet, the national system similar to EIONET. NNB could benefit of both infrastructures, as far as its BioCASE can be hosted on the relevant logical gates.

V. CONCLUSIONS

NNB has started and is still supporting an interesting cooperative effort among the biodiversity community in Italy. The benefits are expected also outside this community, in terms of best practices that are available for improving data interoperability in the public sector.

An amount of about 1.5 million records are already shared. It is foreseen that this amount of available knowledge will progressively increase.

While already exploiting open reliable SW solutions, NNB will probably have to improve their integration in the context of the current ITC infrastructure of the public administration, specifically in terms of data specifications.

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SySPE Solution and IT-for-Green Communication through Web Services

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Abstract—Corporate sustainability and sustainability management have become a key issues in modern organizations to achieve a more balanced and sustainable development. Nowadays IT supports to environmental and sustainability behaviours in business processes and it is part of the solutions to improve the sustainability performance in organizations. IT-for-Green is a project that proposes a new generation of Corporate Environmental Management Information Systems that allows to incorporate the strategic sustainability integration. The main motivation of this research was fill partially the important gap in relation with one uncover goal of this project “the integration with other applications”. The paper explores the architectural elements and the possibility to integrate the IT-for-Green project with the System of Sustainability Performance Evaluation using Zend Framework for web services generation, to add some future functionalities to IT-for-Green. A first web service definition and generation was designed.

Keywords— *sustainability management, solutions integration, web services Introduction*

I. INTRODUCTION

The recent growth in corporate sustainability made organizations consider this area as a key success factor that must be managed [1, 2]. IT plays an important role in sustainability management, specifically in sustainability performance evaluation [3-5]. Although IT has environmental impacts during its lifecycle, as a positive part, IT supports eco-controlling and efficiency in organizations.

The last fifteen years have raised the support of IT to the environmental and sustainability behavior in business organizations [4, 6, 7]. Different concepts have been popularized through the academic and business world, e.g. Green Information Systems (IS), Green IS & IT, Green computing, Green IT and IT-for-Green. All are related to first-order effects (negative environmental impact of IT) and second-order effects (positive impact of IT in business processes). IT-for-Green is one of the newest concepts of the second-order effects and refers to the positive impact of using IT on business and economic processes. This perspective considers IT as part of the solutions to eco-sustainability [7].

Established tools for strengthening IT support are Corporate Environmental Management Information Systems (CEMIS), but those are not sufficient yet to achieve the strategic sustainability integration [8, 9]. For that reason, the project IT-for-Green started in 2011. IT-for-Green cover the complete product life cycle from input, transformation and output. It proposes a new generation of more strategic CEMIS, which

should be able to support the company’s decision makers in all stages of product life cycle. Organizations need to track their sustainability goals and the goals of all their branches in a continuous way. The sustainability indicators are a good tool to compare sustainability business performance in different branches setting an internal sustainability benchmarking. Managers prefer the condensed information for a quick understanding of the whole business picture, identifying setbacks and progress related to the overall performance.

The main motivation of this research was oriented to fill partially the important gap in relation with one uncover goal of this project “the integration of IT-for-Green with other applications”. Isolated applications tend to become problematic after a few years in use, when their integration in changing IT-environments becomes more difficult. IT-for-Green with a modular approach avoids that problem. The idea of add further functionalities from other applications using web services as a platform is a goal to improve the cover areas of IT-for-Green CEMIS. Also further contribution to the internal benchmarking of organizations through the strengthening and upgrading of reporting functionalities.

Communication and reporting are key elements of organization’s sustainability management. For that reason the idea of System of Sustainability Performance Evaluation (SySPE) developed for Cuban organizations [10], can be included as a future extension of web services collection for the IT-for-Green project.

SySPE is a tool to support the storage, retrieval management and integration of different sustainability indicators. The organizations’ managers set the indicators’ goals, related to the business performance into the application. SySPE helps to calculate the Corporate Index of Sustainability Performance (CISP). This index serves managers to discover which is the overall compliant of sustainability business goals and include the perception of different stakeholders. The application allows the graphical representation of CISP and visualizes the improvement potentials of indicators to redirect the organizational efforts.

SySPE functionalities can help to track business sustainability behavior and continuously improve the internal benchmarking. The main objective of this paper is to search architectural elements to integrate the IT-for-Green project with SySPE. The paper explores the possibility of effectively harmonize these

two systems, using web service with Zend Framework to add some future SysPE functionalities.

The paper outline is structured in (i) introduction, (ii) theoretical review of sustainability management and IT support, (iii) IT-for-Green and SysPE descriptions, (iv) web services definition and practical example and finally (v) future steps and conclusion.

II. CORPORATE SUSTAINABILITY AND SUSTAINABILITY MANAGEMENT

The recent boom in corporate sustainability, derived from the inclusion of the concept of sustainable development at organizational level, has led organizations to consider this area as an element that must be managed. Solve possible conflicts related to the dimensions of sustainability in the company, becomes a challenging task for decision makers. The first definitions of corporate sustainability were a faithful translation of the concept given in [11] at business level [12,1]. Others like SAP defines sustainability in a business environment. Sustainability requires us to consider environmental, social and economic aspects at the same time. If you are able to manage the risks and the opportunities holistically, it will lead to increased business success in turn [13].

Managing corporate sustainability is a major challenge for companies to demonstrate their contribution to sustainable development in spite of the difficulties in measuring the performance of the corporate sustainability [14]. The sustainability management is the formulation, implementation, and evaluation of both, environmental and socioeconomic sustainability-related decisions and actions [15]. The main objective of corporate sustainability management is balancing the organizational performance in the economic, social and environmental improvement opportunities identified simultaneously [16-18,14]. Sustainability management includes the internal development of environmental and social measures as well as the external contribution to the sustainable development of society and the economy [19].

Sustainability management are all the actions taken by the organizations to track and balance the business performance in economic, environmental and social areas; maximizing positives impacts and minimizing negatives.

Both concepts have an indissoluble relationship and have extreme significance to make the organizations more sustainable and reduce their negatives impacts and maximize the positive ones.

III. IT SUPPORT FOR CORPORATE ENVIRONMENTAL MANAGEMENT AND SUSTAINABILITY

The business has a great responsibility in the process of transition to a more sustainable development (SD). SD is a social concept, and is being increasingly applied as a business concept under the name of corporate sustainability [11].

In recent years, some tools had been developed to help organizations in the long path of sustainability. The role of IT to support environmental and sustainability management and reporting had being strengthened for the IT capabilities [4, 6, 7,

12-14]. Decision Support Systems are emerging as a suitable solution in the field of sustainability planning and control of complex systems [15]. According to [6] Specialized tools are: SAP Sustainability Performance Management (SuPM), Enablon SD-CSR, SoFi and credit360, and STORM. All these solutions are on the market as a commercial solutions difficult to access for countries like Cuba with a difficult economic situation and low level of internet access.

Another important tool is the project "Solution and Services Engineering for Measuring, Monitoring, and Management of Organizations' Environmental Performance Indicators" (OEPI). This is an international research project supported and funded by the European Commission within the Seventh Framework Program [16] which is related to environmental performance indicators. A fundamental goal of the OEPI is to bridge the gap between various sources and types of environmental information and users of different backgrounds by providing an integrated information source [17]. OEPI provides to business users with an inter-organizational platform and tools to: provision and share environmental performance indicators across the chain and incorporate them in intra- and inter-organizational processes.

Other applications of IT solutions to support the relation between the organizations and the environment are: 1) ProPlaNET: a web based tool which supports sustainable project planning based on e-Participation and Web 2.0 [18]; This web provides a comprehensive framework to deal with the decisions support in relation to the planning process including a large quantity of indicators, stakeholders interests and the transparency of the decision process 2) SIMASE (acronym in Portuguese): Information System for Environmental and Corporate Sustainability Monitoring, is a software framework for social and environmental monitoring for diagnosis of organizations in terms of sustainability [19].

All of the above evidences how the role of information technologies has increased in recent years to support environmental and sustainability information in order to support business decisions and accomplish organizations' sustainability goals.

According to [20] conventional CEMIS are not sufficient to achieve sustainability integration, a new generation of more strategic CEMIS will be able to support the company's decision makers. IT-for-Green enrich traditional CEMIS using an integrated approach of handling processes [21] using workflows.

IV. METHODOLOGY

The research problem was identified as the necessity to make interoperable IT-for-Green with other applications to cooperate and use in relation with distributed applications in an open environment. The idea of add further functionalities from other applications to upgrade IT-for-Green is a goal to improve their cover areas.

The research method to develop the application was a multi methodological approach for Information System research called System Development (SD) [22, 23]. This method perform the research through exploration and integration of

available technologies to produce an artefact [22]. According with [22] based on [23] the systems development method consist in three steps: 1) concept building: investigating the functionality and requirements of the system and studying other disciplines for other ideas and approaches; 2) system building: the construction of the prototype system through the following steps: develop a system architecture, analyze and design the system and build the (prototype) system; 3) system evaluation. SD can be useful to consider as part of the exploratory stage of IS study.

The firsts step was accomplished with the description of the two systems. Later a web service definition and design and finally the validation of the web service.

V. IT-FOR-GREEN PROJECT AS A CEMIS SOLUTION

The principal aim of this project is “increasing the environmental friendliness of companies and their processes by means of ICT” [20]. IT-for-Green¹ proposed to research and create a new generation of Corporate Environmental Management Information Systems (CEMIS) which is able to support the company’s decision makers.

The system is built in a modular manner [20, 24, 25] and the modules are:

Green-IT: Organizations have to deal with energy efficiency as a relevant element to reduce their IT infrastructure carbon footprint and the potential of their climate change impact, through the optimization of their electricity grid. This module is oriented to support energy efficiency and data modelling; it helps to calculate the energy requirements of a data center and compares the results with reference data to optimize energy use and costs.

Green Production and logistics: This module gives insight on two basic CO₂ producing systems, namely production and logistics. For both systems there is a subsystem that models the existing processes and non-existing processes, so both can be compared to each other and to those of other companies.

Sustainability reporting and communication: The goal of this module is to collect and manage information about the real contribution of companies to sustainable development and stakeholders’ interaction. The module handles economic, social and environmental information, necessary to current and future stakeholder demands. Reports are elaborated with the accepted guidelines GRI G3, but also other kind of reports can be transformed into a schema to be generated by the application.

IT-for-Green Next Generation CEMIS is built in a modular way follows the Service-Oriented Architecture (SOA). The modularization of IT-for-Green serves to different purposes: better integration in new IT environments, with IT-for-Green’s modules only a module has to be renewed, not the whole application; the possibility of modules customization in relation with the enterprise needs (they don’t need to acquire the whole package); the easy development, a modular system with loose coupling is easier to develop and maintain.

The platform is designed to be open and extensible for new nodules and services through a workflow-based and service-oriented platform [24, 25]. According to [21] the runtime environment comprises of the core building blocks or components: a Green Service Mall, a Workflow Engine, an Event Engine and a user interface, to handle the internal and external services and business processes.

Green Service Mall is the component that deals with web services, specifically it is a service repository where the web services can be published and discovered by consumers to satisfy their necessities.

The Workflow Engine is oriented to map the business process and it allows different tasks such as adding, updating, and deleting workflows; it is responsible for the system workflow execution and management, interacting with the service consumer and the workflow editor.

The Event Engine is a component of the CEMIS with the main task to compare pre-established (environmental) requirements (e.g. water consumption, CO₂ emissions, etc.) with the current variables’ performance and to detect possible violations and generate warnings and alarm messages automatically. The Event Engine is composed by different subcomponents like: management, executor, timer, condition model and Data Access Objects (DAO).

The User Interface is the component layer between the CEMIS and the users and can be operated using any kind of web browsers.

VI. SYSTEM OF SUSTAINABILITY PERFORMANCE EVALUATION

SySPE is an informatics solution born in 2012, impelled by the necessity of the Cuban energy sector as representation of Cuban business organizations to respond the pressures derived of the inclusion of Sustainable Development concept at business levels. It supports decisions associated to sustainability performance and provides an internal benchmark and a reporting tool to satisfy stakeholder’s information requirements. SySPE supports social, economic and environmental indicators related directly with organization performance distributed over key areas like: financial returns, costumers’ satisfaction and stakeholders’ interests, internal process and learning and growth. The idea of the Sustainability Balanced Scorecard (SBSC) was used, to pursue the balance among the perspectives and the economic, environmental and social pillars [26-28].

Nowadays Cuban companies have several difficulties to include sustainability issues into business strategies. Many Cuban corporations have defined strategies with sustainability topics included but the strategy fails when it is deployed. SySPE is built to support a sustainability performance measurement network to assess the strategy and achieve business long term value generation. SySPE has three modules (Figure 1).

¹ It was a project coordinated by the Carl von Ossietzky University of Oldenburg in joint effort with other German universities and business organizations. It was financed by the European Research and

Transfer Network for Environmental Management Information Systems (ERTEMIS)

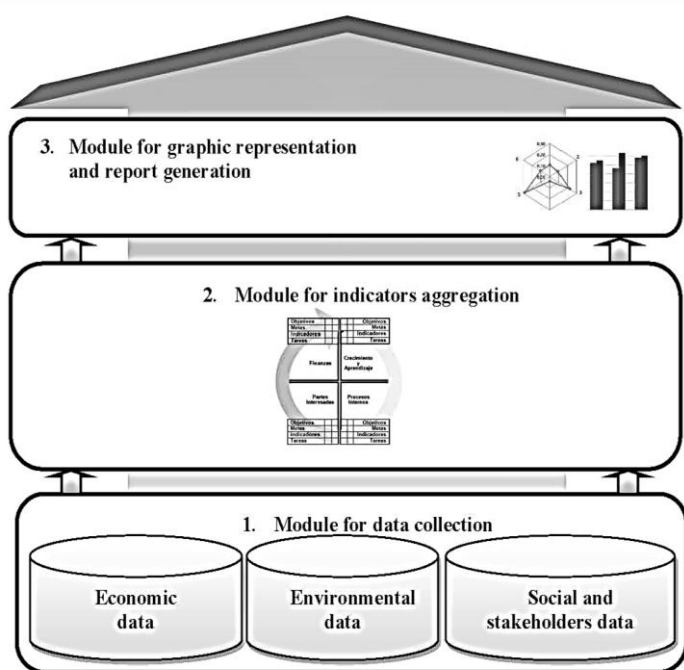


Figure 1: Modules of SySPE application [10]

The first module is data collection: this one is related to the collection and storage of indicators defined by business managers and regulatory standards.

The SBSC perspectives definitions belong to this module. Other actions are the update and elimination of information. These actions will be restricted to a small group of users that could interact with the module.

The second one is indicators aggregation: this module allows setting the sustainability indicators defined over the SBSC perspectives and assign weights for indicators and perspectives to calculate the Corporate Index of Sustainability Performance. The CISP is based on the Corporate Sustainability Measurement Hierarchy and follow the suggested construction frame recommended by [29]. The first step was the indicators selection, the judgment of indicator's impact and the data collection. The second big step was the indicators normalization process with the distance to a reference (or goal) method. The CISP idea is synthesized in an index the progress or setbacks in corporate sustainability performance to verify simple and continuously way if the managerial efforts, organizational management instruments and environmental training are translated into a better or worse business sustainability performance.

The third and last module is graphic representation and report generation: this one allows users and stakeholders to visualize the behavior of CISP and sustainability indicators during a selected period and represent graphically the behavior of indicators and indexes.

SySPE solution intends to cover a poor explored area in Cuban organizations; linked to the support of IT to sustainability performance management and business sustainability benchmark. The main goal is to support sustainability data and

indicators to guide business managers and stakeholders to redirect organizational efforts.

VII. WEB SERVICES FOR SOLUTIONS INTEGRATION

SySPE and IT-for-Green are two solutions that support organizations in relation with the environment and sustainability. Since the design point of view they run in different technologies and pattern designs. IT-for-Green uses a Service Oriented Architecture design pattern and SySPE implements a Model-View-Controller pattern. In order to upgrade the IT-for-Green solution, is possible to take advantage of SySPE functionalities and reporting capabilities. To achieve this goal one question should be answered: How to integrate two systems during the runtime effectively? A method of data exchange is needed.

An effective solution is a web service as a way to expose the SySPE functionalities and make it available through standard web technologies to facilitate applications communication reducing applications heterogeneity. Web services promote the specification-based cooperation and collaboration among distributed applications in an open environment [30]. Web services have become a widely used form of adding depth to online applications and allow developers write applications that are interoperable with external services located anywhere in the world [31]. Web services use different web standards like XML and SOAP to tag and transfer the data, Web Services Description Language (WSDL) is used for describing the services available and the Universal Description, Discovery and Integration (UDDI) is used for list what services are available [32].

IT-for-Green have a web service provider, which allows handle with the new services which are not available in the stock version of the CEMIS [25] and a special controller can be implemented using Zend Framework to integrate through web services with SySPE. To establish the first steps in the integration between those applications, a web service architecture was defined (Fig. 2).

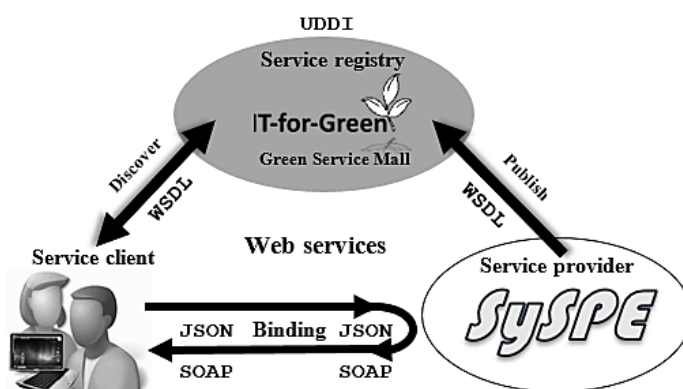


Figure 2: Web services architecture.

It shows how the service client contact and discover the web service in service registry (Green service mall). The service registry answers with a service description indicating where to locate the service and how to invoke it.

The service provider, SySPE, similarly has to generate service descriptions for those services, making this services known and publishing the corresponding service descriptions in a service registry. The service registry uses all the services descriptions to create a service collection and make it available when services clients request arrive.

SySPE validates the service request and sends structured data in an XML file, using the SOAP protocol. The XML file could be validated by the service client using an XSD file.

Zend Framework (ZF) was used to create the web service. ZF is a PHP framework and was used to develop a SySPE application and provide components to work with web services. The components provided by the framework, for web service creation, are mature and well-designed, they offer good integration with the rest of the framework and are comprehensively documented; the entire code is unit-tested and peer-reviewed and there is no licensing fuss around Zend Framework [33]. ZF includes a number of components that enable to work with existing web services as well as create your own. Zend_Service provides a straightforward interface to a number of popular web services like: Amazon, Twitter, Yahoo and Google's services [34].

As a practical example was defined the web service called, to orient the example in one of the future direction identified by [21] (import of sustainability indicators) as base of business sustainability performance to upgrade module three. GET_INDICATORS web service allows obtaining all the indicators with their respective fields stored in SySPE. For it was created a PHP class named Services with one function GET_INDICATORS. This function establishes the connection with the database, executes the query and return the result in JSON (JavaScript Object Notation) format. JSON is a format for transferring data from one program or system to another and allows making the file with the class names more readable for humans.

ZF allows automatically generate a WSDL XML, based an existing code. To test the WSDL file a PHP class called client was created. The class defines a function WSDL_call and uses a Zend_Soap_Client by pointing a Zend Soap Client instance at the URL returning the WSDL in an XML format to test the service.

The web service is published at Green Service Mall. This component is responsible for the registration of external and internal services offered by IT-for-Green solution to be discovered by the consumers.

VIII. WEB SERVICE VALIDATION

After the web service design a review and validation of the WSDL is necessary to evaluate the web service. To achieve this, the web services was invoked from "Web Services Validation Tool for WSDL and SOAP 2.1"². The Web Services Validation Tool for WSDL and SOAP analyzes and reports problems in SOAP messages and WSDL schemas before implement web services applications. The validation test consisted in visualize the web service input and output to check the desire outcome,

² This software was developed and supported by IBM Corporation.

the JSON file with all the indicators stored in SySPE application with their respective fields.

The next step was the validation through the SOAP messages. A SOAP message was introduced in the XML file to be validated. The web services GET_INDICATORS was invoke using a "parameter" called "EXAMPLE". The SOAP request is transmitted to the server and the successful SOAP response from the Web Services Validation Tool was received.

This web service allows the communication, interoperability and integration of those platforms through a first example GET_INDICATORS. The web services are a powerful tool to achieve the communication and integration between those systems.

IX. OUTLOOK

The future direction of this research is oriented to implement the key functionalities of SySPE, the calculus of Corporate Index of Sustainability Performance and graphic generation as a web service to be used by consumers of IT-for-Green to analyze the indicators associated to production process, products or services as internal benchmarking of organizations. Since the practical point of view this initial stage is a first step to accomplish the goal of integration with SySPE.

X. CONCLUSION

Nowadays the organizations need the support of IT resources to monitoring, controlling and supporting decisions making processes in relation with sustainability performance as a real imperative. IT-for-Green and SySPE are two solutions emerged of this needs. The first covers the complete product life cycle and the second allows tracking business sustainability indicators to help managers to discover which is the overall compliant of sustainability business goals using the CISP, which includes the perception of the different stakeholders.

The communication and integration between those solutions is possible through the web services implementation. To achieve this goal, a web services architecture was defined between IT-for-Green and SySPE. A web service GET_INDICATORS was defined using a bottom-up model were is possible to implement classes first, and then, use a WSDL generating tool to expose methods from these classes as a web service. ZF was used as WSDL automatically generating tool based on existing code.

XI. ACKNOWLEDGMENT

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The BIOSCORE 2 project: Developing a Model to Compare Biodiversity Effects of European Nature Policy Scenarios

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Abstract— *The concept, model framework and first results of BIOSCORE 2 are described. The model allows making projections of future nature quality and biodiversity situations in Europe, based on empirical relations between species occurrence and environmental pressure factors like land use change, intensification, air pollution, water use, fragmentation, climate change and nature management.*

Keywords— *Modelling, Spatial Statistics, R, ArcGIS, Databases, Environmental Pressures, Climate Change, Land Use, Nature Policy, Scenario, Biodiversity, Generalised Boosted Model (GBM), General Linear Model (GLM)*

I. INTRODUCTION

The European Union has subscribed to the Convention on Biological Diversity (CBD) treaty, which aims to halt biodiversity loss. A main EU-policy to achieve this is the implementation of the Birds and Habitats Directives. An earlier target to achieve the target of halting loss by 2010 was not met, and now a new target is set for 2020 and a vision for 2050. The question is, are the current policy instruments likely to be successful? If not, what policy alternatives could be considered? And how could one assess the potentials of such alternatives? These questions will gain rising political interest in the near future, when the European Union will publish its Natura 2000 Fitness Check, the mid-term evaluation of EU's main nature policy instrument. The recent EEA State of Nature Report (European Commission, 2015) shows that large proportions of both the nature 2000 areas (60%) and of the species (77%) still have unfavorable status, and progress to favorable status is slow.

In order to answer questions like these on the European scale, a model is needed that gives insights in the effects of diverse policy measures on biodiversity. Such models are scarce and available models often focus on individual environmental pressures like climate change or land use changes. The BIOSCORE 2 model that has been recently developed aims to provide insights in the effects of changes in a number of important pressures. The pressures themselves are not calculated in BIOSCORE, but need to be derived from other available models such as IMAGE and CLUE. These pressures are climate change, land use change, air pollution by nitrogen and sulphur deposition, intensification of agricultural

use, water use, habitat fragmentation, forest and nature management, disturbance by roads and urbanization. These factors have been selected based on a review of both scientific papers and policy documents.

II. CONCEPT OF THE BIOSCORE 2 MODEL

A. Basic principles

BIOSCORE can be considered to be a habitat suitability model. Its basic concept is that the occurrences of plant and animal species will be influenced if important environmental factors influence their habitat quality. Various pressures may affect this habitat quality positively or negatively. Local sub-optimal habitat quality for a species will lead to a lower Chance of Occurrence (COO) of the species on that location. For each species, the optimal values of environmental factors and tolerance to individual pressures will be different. So a change in one pressure will affect COO's of species in different ways.

To derive species specific dose-response functions BIOSCORE 2 uses a combination of spatial regression modeling techniques. We make use of both Maxent and Boosted Regression Trees (BRT) in a suite of R-scripts called TRIMMAPS (Hallman et al, 2014). Both are machine-learning techniques, able to handle non-linear relationships and account for synergistic effects of different factors. Maxent is widely used in ecological studies, including effects of climate change. BRT is used less widely, but is better equipped to use presence-absence data. Both methods use species distribution maps and maps of environmental factors as input.

Since the dose-response functions will vary across species, we looked at a large number of species from different groups. In the current version of BIOSCORE, dose-response functions are included from birds (250), mammals (100), plants (850) and butterflies (100). All species that have been selected are relevant with respect to European policies. The selected species are protected under the Bird or Habitat directives, typical species of protected Habitats and/or Red List species.

III. THREE-STEP APPROACH OF THE BIOSCORE 2 MODEL

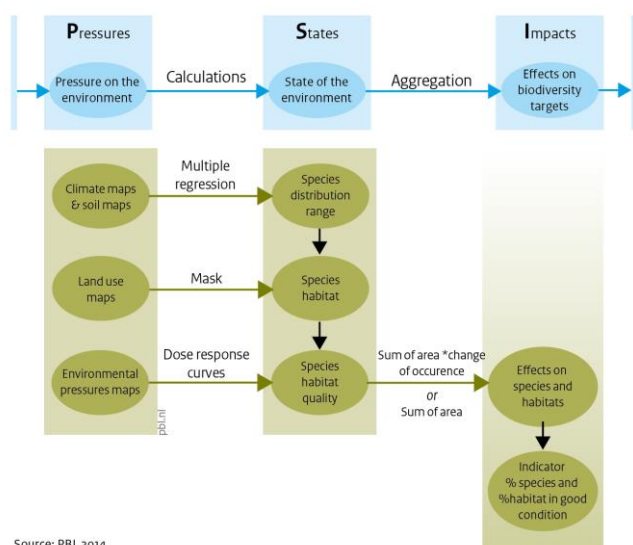
Figure 1 shows a schematic of the model steps in BIOSCORE 2 and how these fit in the well-known DPSIR chain. It

calculates effects of pressures (e.g. acidification) on states (abundance and numbers of species) and their impact on biodiversity targets. The effects of pressures are calculated by means of Dose-response functions for about 1300 selected species. This process is subdivided in three subsequent steps.

First, in a multivariate analysis, the responses of each species to a set of climate and soil factors are calculated. These factors include average temperature, temperature sum in growing season, precipitation, annual moisture index, evapo-transpiration, isothermality and soil type (clay-sand-peat). The climate maps were taken from the BIOCLIM website, and were produced by the CSIRO Mk3 model and IPCC IV A1/B scenarios (Kriticos et al, 2012) for the year 2050. Maps of these factors were combined with recorded occurrences of each species in a GBM (Generalized Boosted Model) analysis.

Step 1 produces not only dose-response functions, but in combination with climate maps also maps of the potential distribution per species, for a future year. By using climate data from 2010 and 2050 we could compare the predicted species distribution maps against available distribution maps and maps in available climate atlases.

Input and calculations of Bioscore as part of the DPSIR chain



Source: PBL 2014

Figure 1 Conceptual scheme of BIOSCORE 2

In step 2, we determined the preferences of each species for a set of (CORINE) land use classes by comparing species distribution maps and land use maps. Again, when the derived dose response functions are applied on land use maps we could map available habitats within the predicted species distribution range. As to be expected, specialized species were limited more severely than cosmopolitan species.

In step 3 the effects of environmental pressures on the available habitats are calculated. This is done for the levels of atmospheric deposition of nitrogen and sulphur, water use intensity, agricultural land use intensity or total nitrogen input, occurrence of roads and infrastructure, and habitat

fragmentation. As input for these calculations, a series of pressure maps were used (see next section). Again, by combining the derived dose-response functions with available environmental maps we can calculate COO's per species.

For a number of relevant pressure factors, maps were selected (see fig 2).

Pressures included in BioScore 2.0

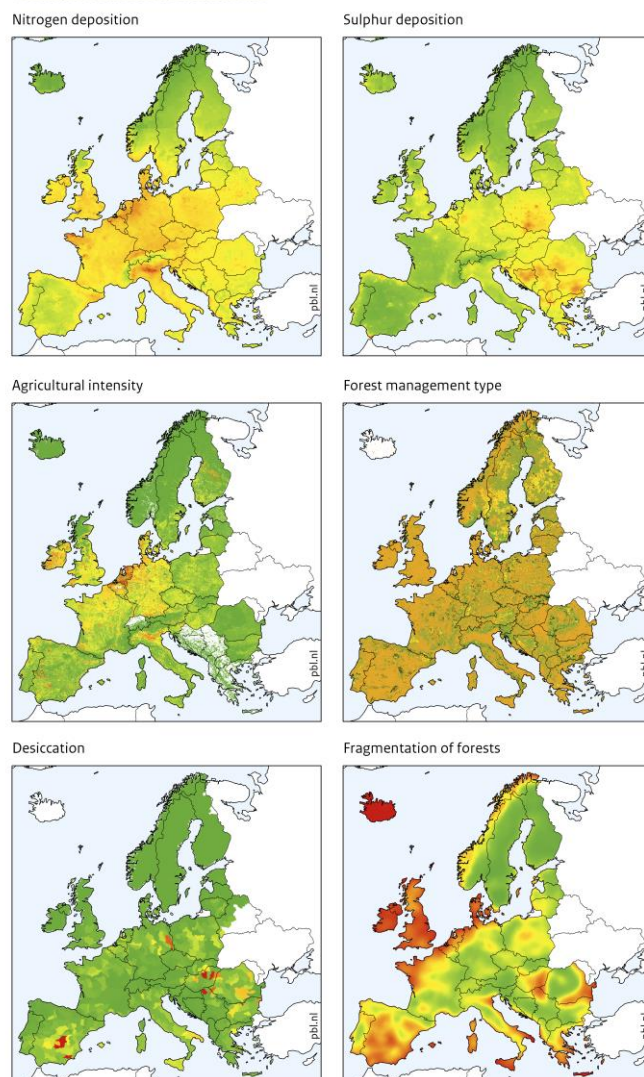


Figure 2 Maps of environmental pressures that were used to derive dose-effects curves for each species.

In order to evaluate the effects of these pressures on species occurrences, an approach was chosen that is different from the one with the climate factors. We have a strong interest in evaluating and testing the individual effects of each pressure factor. It is relevant to compare policy options for Europe that address reductions of individual pressures, and be able to understand and explain the effects of such policy options in details. Therefore, we derived the response curves of each species to each pressure with a different spatial statistics method: GLM (Generalized Linear Modeling).

IV. MODEL FRAMEWORK AND DATA

The BIOSCORE 2 model is implemented in a cross-platform concept. Spatial statistics are being calculated with TRIMMAPS, a combination of standard R-packages and dedicated R-scripts. Current and future distributions of land use (based on CORINE), species and pressures are calculated and maintained in ArcGIS. For scenario management, data preparation, processing of results and indicator production a SQL-server database with a MsAccess front-end is used.

The amount of data that is handled is rather large. Modelling the whole of the European terrestrial area in 5*5 km grid cells with underlying information of land use in 1*1 km grids, requires 250.000 units of calculation, for each of 1300 species. Data storage needed for one run is about 12 GB. Parallel processing on several machines is possible as the model calculates no changes in interactions between the selected species (these are assumed to be constant).

V. APPLICATION IN EUROPEAN NATURE OUTLOOK

The BIOSCORE 2 model will first be applied in the context of a European Nature Outlook. In this project, four different scenarios are being developed for the future of nature and biodiversity in the EU in 2050. These scenarios will be based on different perspectives on nature. These perspectives represent different sets of values, goals and measures regarding to nature and biodiversity. In addition the Outlook will examine the effects of a reference scenario for 2050.

In the various European scenario studies major changes in climate, land use and land use intensity have been expected to occur towards 2050.

The climate data in our reference scenario are based on BioCLIM 2050. As in most scenarios land temperature in Europe is projected to increase. The largest temperature increases during the 21st century are projected over eastern and northern Europe in winter and over southern Europe in summer. Heat waves are projected to become more frequent and last longer across Europe over the 21st century. As in most climate model projections continued precipitation increases are presumed in northern Europe (most notably during winter) and decreases in southern Europe (most notably during summer).

The land-use and land intensity changes in our reference scenario are based on the recent Volante "Best land use in Europe" scenario (Volante, 2012), in which the trends between 2010 and 2040 have been extended towards 2050. In most studies, agricultural area in the EU is projected to decrease slightly or remain at the same level, while production increases. Underlying drivers are the growth in population and GDP next to changes in trade (including trade policies), climate and agricultural and biofuel policies that finally define the production and agricultural area needed. The reference land-use scenario used in this study shows a decrease of 3,5% in cropland, a 5,0% decrease in pasture and an increase in agricultural intensity. Based on an inventory of recent scenario studies, Tucker et al. (2014) expect that such past trends of polarization in land use (i.e. intensification on one hand and abandonment at other locations) are likely to continue. The losses of agricultural land are consequences of urban expansion

and abandonment of (marginal) agricultural lands (i.e. mosaic landscapes).

As in all recent scenario studies, the reference scenario assumes also a future increase of built-up area in Europe. The built-up area in the used reference scenario increased with 15% relative to the situation in 2010. Growth is found in major cities, both in Western Europe (e.g. London, Dutch Randstad and Berlin) and in Eastern Europe (e.g. Budapest, Prague, cities in Poland). In addition the scenario assumes further urban sprawl, because there are currently no policies to restrict this process.

Scenario studies often assume a further increase of forest area in the EU, either based on an extrapolation of past trends (UNECE/FAO 2011), or derived from land use projections. In the chosen Volante scenario, the area of forests increases by 6,5% between 2010 and 2050. As in other scenarios, this increase is a result of the change in agricultural land and not a result of active (re)planting of forests due to, for example, a growing demand for wood or biomass. Abandoned agricultural land is assumed to undergo a succession into forests. The increase in urbanization and the land abandonment causes a decline in the area of semi-natural vegetation, although it is assumed in the reference scenario that protected Natura 2000 sites are maintained and protected from land conversions.

The above mapped changes in land use have been translated in GIS to other BIOSCORE input maps such as habitat fragmentation and proximity to urban area. The input maps of proximity to roads have not been altered. Input on the levels of atmospheric deposition of sulfur and nitrogen have been based on the Current Legislation scenarios of IIASA. In this scenario all current legislation is included, such as best practices for industry, fuel and emission standards in transport and national legislation including elements of EU law, i.e. the Nitrate and Water Framework Directives. It is assumed that all of these regulations will be fully complied within all Member States according to the foreseen time schedule. Progressing implementation of air quality legislation together with the structural changes in the energy system will lead to a decline of SO₂ emissions and depositions in the EU towards 2030, followed by stabilization afterwards since no further reduction policies are assumed. According to the scenario the total SO₂ emissions will in 2030 be almost 70% below the 2005 level. Also for NO_x emissions, implementation of current legislation will lead to a reduction of about 60%. With respect to NH₃ only slight changes in total emissions in the EU-28 are expected up to 2050, although NH₃ emissions are also subject to targeted controls in the agricultural sector and will be affected as a side impact of emission legislation for road transport.

VI. PRELIMINARY MODEL RESULTS

The calculations of the effects of all changes in 2050 as mentioned above are in progress at the moment that this paper is being written. Until now BIOSCORE 2 has produced potential distribution maps for about 1300 species in Europe, based on 5*5 km grids and underlying 1*1 km. These maps of chances of occurrence were post-processed to indicators like average gain/loss of change of occurrence. These indicators

can be analyzed on a variety of geographic details, e.g. region, nature type, species group, Natura 2000 area, etc. The presented results in table 1 focus on the terrestrial area of EU28.

Table 1 shows the preliminary results of the combined effects of the changes in various environmental factors in 2010 and 2050 for some important indicators. Results show that the computed average species occurrence decreases to a level of about 80% of the situation in 2010. Although found in species of all groups, the average change in occurrence varies largely among species groups. The largest decrease is found in plant species, whereas butterflies on average increase. Further analysis may clarify whether this is due to rise of temperature. Although the average change in occurrence indicates an overall decrease in 2050, a large number of species actually show increasing or stable occurrences.

Based on analyses of changes in habitat types losses are relatively large in semi-natural grasslands and for example dune habitats, whereas species of various forest habitats increase (data not shown). The changes also vary across the various biogeographical regions of Europe. Especially in the Boreal and Alpine regions a relative large number of non-native, but protected species increases.

Table 1. Preliminary results of BIOSCORE 2: comparing the current situation with a reference scenario for 2050 (Business-as-usual).

	Average occurrence relative to base year	Percentage of species with a decrease	Percentage of species with a large decrease
Plants	0,71	75%	62%
Birds	0,96	48%	40%
Butterflies	1,08	31%	19%
Mammals	0,94	61%	47%
Total	0,79	65%	53%

VII. CONCLUSIONS AND DISCUSSION

Preliminary results of BIOSCORE show that a future change in the occurrence of protected species is on average negative. This finding is inline with the conclusions from the recent European State of the Environment which state that 'underlying drivers of biodiversity loss are not changing favorably' (European Commission, 2015). In the business-as-usual scenario for 2050 of the last Global Biodiversity Outlook, Europe's terrestrial biodiversity measured as mean species abundance (MSA) was also projected to decline (CBD, 2014). In that study the MSA that potential natural vegetation could support in 2050 relative to 2010, was expected to drop 24%, a value close to what is now calculated with BIOSCORE.

In accordance with the conclusion by the State of the Environment, results of BIOSCORE indicate that it will be

very challenging for Europe to meet the overall target of halting the loss of biodiversity by 2020. The positive trends in a large number of protected species as computed with BIOSCORE, on the other hand, is promising and might be a result of nature conservation in Natura 2000, lowering of the atmospheric deposition levels or the increase in forest area in reference scenario. However, increases in occurrences of these species might also be caused by to climate change.

The preliminary results of BIOSCORE need to be further tested and analyzed to unravel the effects of the changes in the various environmental factors. As many of the direct, and all of the indirect influences on biodiversity loss, arise from a range of sectors and policies, such analyses might reveal possibilities for economic sectors as well as regional policies to reduce the pressures on Europe's biodiversity. As such the BIOSCORE 2 model seems to provide policy relevant insight in policy-relevant effects of changes in various environmental conditions. However, at the same time model improvement must go on and for example more species groups need to be incorporated.

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Web Environmental Information System for Corporate Performance Evaluation and Reporting

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Abstract — *Many business activities and procedures influence the environment. Their environmental impacts have to be assessed. We consider companies where the procedure of measuring environmental performance (EP) is applied through an environmental management system (EMS). The paper surveys the methodology that is designated for the environmental performance evaluation of companies in the food-processing sector and introduces the architecture of the Web environmental benchmarking and reporting system (WEBRIS) that has been developed. The WEBRIS consists of several modules that can be separated into two main groups – data collection and data retrieval, which is introduced in the paper. Web information system was built as a transactional system utilizing a relational database, which forms the main data storage system.*

Keywords — *Benchmarking; Corporate sustainability; Corporate reporting; Corporate performance; EMS; EP; EPE; KPI; frameworks; Nette; PostgreSQL*

I. INTRODUCTION

The process of improving performance by understanding, identifying, adapting and implementing best practices is called benchmarking, [1].

Benchmarking is based on exchange of information on processes and measurements. This process is resulting in the setting of realistic improvement goals. It is a process of continuous improvement, [2]. The framework based on benchmarking performance indicators and the best practices are examined. It is necessary to determine areas where the company performance can be improved. Although most benchmarking initiatives concern financial and management issues, environmental benchmarking is becoming a major element in the environmental management of companies. Benchmarking can provide an early warning in time to prevent economic, social and environmental harm, [3].

On the other hand, measuring corporate performance is difficult and challenging, [4]. In different decision-making contexts, stakeholders tend to use different criteria and methodologies, thus arriving at different and contrasting assessments of the sustainability of corporate performance in practice, [5].

The current trends of research in the area of corporate performance evaluation and corporate sustainability are discussed by Hřebíček [6, 7]. These papers concentrate on local (Czech Republic) trends in this area [8].

The ICT support tools can be divided into two groups. The first group includes generic benchmarking and the second is for specific benchmarking. Let us mention the best known of them.

e-Bench [9] is a web application for auditing and simulation/modelling. The system then benchmarks these input factors to identify how efficiently they are used by other users in the data-base. e-Bench has been successfully used in the USA, Australia and New Zealand.

Web application named *Environmental Management Assessment and Benchmarking* (EMAB) is designed for the maturity assessment and benchmarking of corporate environmental management efforts [10]. The portal provides the measuring of corporate environmental management efforts, a survey that is based on criteria pursuant to the ISO 14000 family [11] and the EMAS III [12] standards.

The *Safety, Health and Environment Intra Industry Benchmarking Association* (SHEIIBA) [13] Corporate Benchmarking Ltd. (in SHEIIBA) has built and runs bespoke safety benchmarking programmes for industry sectors. Participating companies enter accident and ill-health data into an online form each month. The data is divided by cause and type and can be split into different employee groups. Data can be viewed in graphic or tabular format as fixed periods, rolling years or time spans (up to 12 quarters or years.) The system is currently in use in 14 United Kingdom water utilities.

We introduce the methodology that is designated for the environmental performance evaluation of companies in the food-processing sector and discuss the architecture of the *Web environmental benchmarking and reporting system* (WEBRIS) that has been developed. In our vision, we foresaw two main objectives of the WEBRIS.

Firstly, any company may use such an information system to create various environmental reports and share its data with both its stakeholders and, in the future, with the state administrations concerned with regulatory demands and mandatory corporate reporting.

Secondly, the environmental performance evaluation (EPE) of any company is performed by evaluating its key performance indicators (KPIs). This way, the company can share with the public its environmental performance (EP) or check an EP development progress. EPE can be done through various reports as stated above or through custom dashboards.

Basic high-level requirements for the WEBRIS were:

- to store source company data;
- to compute KPIs according to the selected sector and methodology;
- to generate environmental reports in the selected format for offline storage, printing and archiving;
- to import source company data from its company information system with the prescribed format;
- to provide selected information in the form of reports accessible online to the general public or only to selected persons;
- to provide selected information in the standardized XBRL format for interchange with other systems;
- to provide the possibility to evaluate the company EP anonymously;
- to provide the possibility to define report data and business logic;
- to dynamically generate the XBRL taxonomies for a given report;
- to provide the possibility to customize standardized reports and to generate fully customized reports;
- to provide the possibility to compare reports among the companies of the given sector.

The WEBRIS consists of several modules that can be separated into two main groups – *data collection* and *data retrieval*, which is introduced in the next section. The WEBRIS was built as a transactional system utilizing a relational database, which forms the main data storage system.

We have proposed a further extension of the reporting information system with an XML and XBRL data store to provide greater flexibility. The pilot implementation of WEBRIS has been performed in the set of twenty four SME breweries in the Czech Republic which belongs to C11 - Manufacture of beverages NACE section and which have determined their KPIs.

Another direction of the WEBRIS implementation will be connected with improving the user-friendliness (in accord with feedback) and the integration of complementary methods for measuring company EP, together with an extension into other market segments.

II. MATERIALS AND METHODS

The system WEBRIS is implemented as a web application - regarding the requirements for availability. PHP5 language (PHP: Hypertext Preprocessor) [14] was selected as the language for the application implementation. For cover security, easy extension the application and for the reason of sustainability of application the Nette framework [15] was used. The Nette framework is a MVP (Model View Presenter) framework, which allows us to separate the architecture layers to secure the consistency of the web application. The Nette is an extension of PHP5 language.

Since the WEBRIS application is focused on collecting questionnaires and generating reports, it is necessary to use a database where these will be saved and the reports calculations will be done. MySQL [16] was chosen. Given the complexity of the calculations, MySQL is the best choice.

The frontend Bootstrap framework was used in order to ensure responsiveness of the web design. This technology allows optimization of websites for mobile devices, [17].

III. RESULTS

A. User roles in WEBRIS

The WEBRIS allows the authentication and authorization. In WEBRIS (Figure 1), there are three types of users.

The first type of user is *public user*, who is only allowed to show the Sign in page.

The second type of user – the company allows login or a new registration. After registration the user is offered either to complete a new questionnaire or is shown the original questionnaires. In the case of a user of the administrator type, the user rights are extended with browsing the questionnaires of any company. Naturally, it is possible to register a new user - company on the registration page.

The third type of user is *Administrator*. This user can show or edit the questionnaire of any company. For managing the roles, we implemented the ACL (Access Control List) model, which makes authorization much easier, because the list of roles, resources and privileges is centralized.

B. The WEBRIS architecture

The WEBRIS architecture (Fig. 1) is based on the MVP (Model View Presenter) architecture. Fig.1 shows its architecture. The presentation layer is provided by Latte templates that allow better adaptation of the HTML code. Common visual elements of the information system are allocated to a separate file and included in each partial template. At the level of view Twitter Bootstrap is also used, which provides a responsive image even in mobile devices.

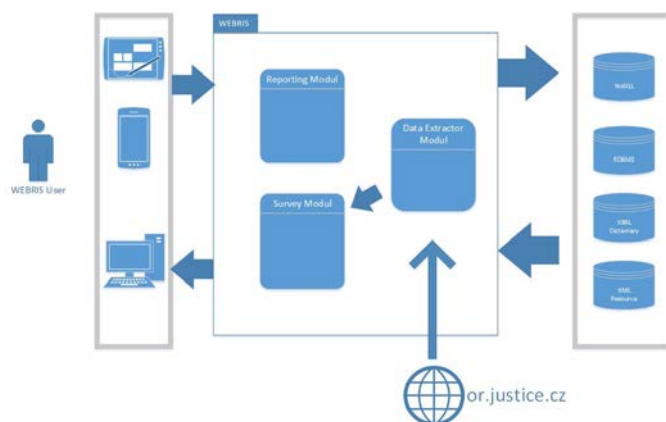


Fig. 1. WEBRIS Architecture

The data layer includes both database systems - the RDB system and the XBRL database.

It is possible to query by both SQL and XQuery languages, because the Data layer exposes their interfaces.

The application layer provides a wide range of APIs to connect the database to various sources; this allows high interoperability of the WEBRIS.

Due to the development of WEBRIS, this application is divided into several modules.

The first module termed *Survey* collects questionnaires and their management. In the case of management, it is deletion or modification of questionnaires.

The second module called *Reporting* provides evaluation (Fig. 2) of the forms, and display of results as a diagram in a comparison with the average for the sector. Diagrams are shown on the client side using the framework Chart.js. This module also allows us to export the final report in XBRL format [18], or PDF.

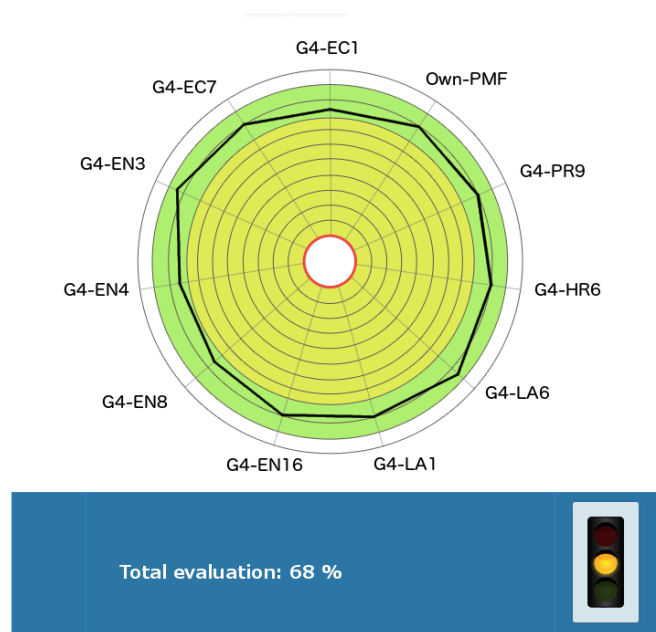


Fig. 2. Final Report

The *Data Extractor* module provides automatic acquisition of values needed KPI calculation for reporting. This module downloads necessary data from the website or.justice.cz. It is necessary to transform data from PDF format using OCR (scanned document) to a plain text format, which is then parsed and automatically added to the questionnaire form.

As one of the key indicators, the *Economic Value Added* (EVA) [19] was used. It defines the difference between the net profit and capital costs. It serves for the estimation of shareholder value.

A pilot version WEBRIS is focused on agricultural businesses, brewing and manufacturing industry.

IV. DISCUSSION

The previous version of corporate sustainability reporting information system was implemented [7, 8], [22, 23] in the past two years.

This prototype was made to ensure that the chosen indicators can be computed and implemented successfully and verify the usability of information system for the end user.

It concentrated on the assessing sustainability of crop production systems for the conditions of the Czech Republic [20] and differs from the new developed SAFA software [21]. In contrast, our application is beside others focused on a mobile access. It contains also the security ALC model.

V. CONCLUSION

The next objective of the WEBRIS implementation will be connected with improving the user-friendliness based on the user feedback and the integration of complementary methods for measuring company performance, together with an extension into other market segments.

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Development of a prototype client/server system for mobile data collection of material flows containing VOC in automotive paint systems using the example of Volkswagen AG

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Abstract — Automotive paint systems include very environmental relevant processes and are complex systems, which complicate the data acquisition for material flow analyses. With the help of a new developed client/server system consisting of three clients, VOC including material data can be captured systematically and locally to build a better knowledge of these consumption data for future balances and calculations. With the help of the mobile client, VOC including material flow data can be captured systematically and locally. It represents a developed guideline of data acquisition to capture such material flows. The mobile client also has to support users during inspections by detecting and identifying the data sources through a map function and a QR-Code function. With the desktop client, users can manage the inspections and evaluate the collected consumption data. The evaluation tables, generated by the desktop client, contain the percentage of the environmental relevant solvents. These tables are useful as an import for a VOC balance sheet tool, which is important e.g. for the VOC directive. The third client, the server client, contains the database and manages the communication between the other clients. Through a verification of the developed solutions practicality, it was demonstrated, that there are a few discrepancies in a paint shop between the present data of the operating data logging and the collected data by the client/server system. These discrepancies were verified by the comparison with the compared data of another paint shop. That means that the data quality increases through the using of the developed client/server system. Also media breaks could be avoided and the spending time for the inspections could be reduced by a good usability and a strict structured workflow.

Keywords — Client/server system, data acquisition, VOC, OpenResKit

I. INTRODUCTION

In the run-up to this study, mass balances were analyzed, which identified paint systems as the automotive sectors greatest emitter of Volatile Organic Compounds-Emissions (VOC emissions). Their share of the solvents containing VOC, while the whole automotive production process, amount approx. 90 % [2]. Automotive paint systems include very environmental relevant processes and are complex systems. These steps are numerous and the materials supply is far away from the application robots, therefore the quality of the

material consumption data of the production data acquisition and their availability are limited. Reasons are e.g. missing data about the exactly position of caused data. Other quality defects of data are results through media interruptions. One more reason are the missing information about the quality, source and derivation of the data [1].

The 31st BImSchV [German Federal Emission Protection Ordinance] set a VOC emission limit of 35 g/m² for Germany. VOC emissions arise because paint and other operating materials that are part of the material input for this process contain solvents and additives. Whilst these materials are being used the VOCs are emitted into the air.

Good data quality is the basis of meaningful material flow analysis. Well thought out data collection is required in order to achieve this. Therefore, the data collection requires, among other things, qualified employees and adequate planning. This includes equipment readable measurement points and establishing a collection strategy. The collection strategy is made up of the data type, the data source types and the resulting collection methods. These three parameters must be known for qualitative information. The following figure illustrates the necessity of these parameters.



Figure 1 Collection strategies [1]

The data type can be split into two categories, namely primary and secondary data. Primary data includes directly observable variables, such as thermometer readings and direct measurements, for example. Secondary data are derived from primary data. They included statistically derived, computed, composed and simulated data.

Data sources, such as measuring stations, can obtain different types of data. These can be calculated data as well as measured data. Knowledge about the data type not only

contributes to the improvement of the data quality but also to guaranteeing the data quality.

The central aim of this present study was to develop a new process for data collection in the material input flow. So data quality and availability for paint systems should be increased and consequently it should ensure more transparent, more qualitative material input information for future material flow management analyses. This newly gained information should help to shape a new foundation for the analysis of materials usage and their solvent emissions [1].

II. CONCEPTION AND ARCHITECTURE

A. Analysis of the painting process in the automotive industry

The development of a software based process for data collection first requires an analysis of the processes of different types of paint shop. Here, there is a distinction between vehicle body and component paint shops. For this study a very large, complex, historically established vehicle body paint shop and a modern, small component paint shop based in Wolfsburg were used as reference models, in order to cover as many of the variables as possible. Despite the technological differences and the products being painted, the process steps did not vary greatly from each other. The vehicle body paint shop process chain that used solvents containing VOCs, consisted simply of five abstract process steps, that are illustrated by the darker sections of figure 2. The initial process step pre-treatment (VBH) and the last two steps roof reinforcement / damping steps (DVD) and cavity preservation (HRK) are left out because these process steps use almost no materials that contain organic solvents [1].



Figure 2 Painting process steps [1]

The illustrated processes are executed sequentially, whereby the application of filler can be omitted in the modern painting process. In this case the functional properties are adopted by a customised base coat. The first layer of paint is applied to the vehicle body in the cathodic dip painting (KTL), after the zinc phosphate coat, and it serves as the bonding foundation for the subsequent paint layers [4]. Subsequently, the underbody is sealed at the sills and plate edges with PVC material, which also emits VOCs, and is covered here under underbody protection (UBS) and seam sealing (NAD) [3]. The filler was originally used, among other things, to smooth out any unevenness on the vehicle body in order to provide as smooth a surface as possible for the chromophoric base coat (BC). After the BC has been applied then a clear coat (CC) is applied [1].

B. Conceptual design

The developing solution is a distributed software system that consists of a mobile client, with which the material input flows could be systematically collected on-site, a desktop client for subsequent work place analysis and evaluation and a server client for storing the data collected (see figure 3). A part of the desktop client data also serves as the input for Volkswagen's

own VOC monitoring tool that is Microsoft Excel based. The required data includes, among other things, a tabulated annual overview of the material consumption volumes, their VOC percentages and the size of the painted surfaces.

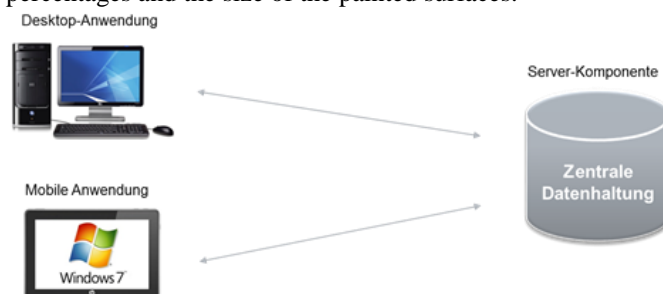


Figure 3 Client/server system communication architecture

C. Architecture

The developed client/server system is technologically, primarily based on the OpenResKit approach, that was developed at the Hochschule für Technik und Wirtschaft Berlin [University of Applied Sciences Berlin] [5]. OpenResKit provides a modular software system with tools and methods that enables open source based use to support the quicker development of the resource efficiency issue [5]. The vision of the OpenResKit approach is to allow the individual areas of a company to communicate with each other via a central interface by making the corresponding small tools available by means of the client/server architecture. Clients can be created for the respective application domains and the information merged so that the data sources remain the same.

III. EXAMPLE APPLICATION

The created client/server system would be practically and prototypically tested at Volkswagen AG in the collection of VOC relevant material flows from two paint shops with the assistance of a typical example of use in order to establish its operational suitability.

The basic workflow in the software system begins with the use of the desktop to create master files. These include, among other things, the plants, fixed price projects, materials and the products to be painted. Under the "planning" tab (see figure 4) inspections of the corresponding paint systems and materials can be generated. In order to efficiently design the creation of the inspections it is necessary to create regular dates for lots of materials at the same time. These inspections are visible in the mobile application as well so that the relevant inspection can be carried out [1].



Figure 4 Creating inspections [1]

Data sources can be localised using card calls in order to support the inspections. The following figure shows such a card in VOC observer, where the two data sources are illustrated by dots.

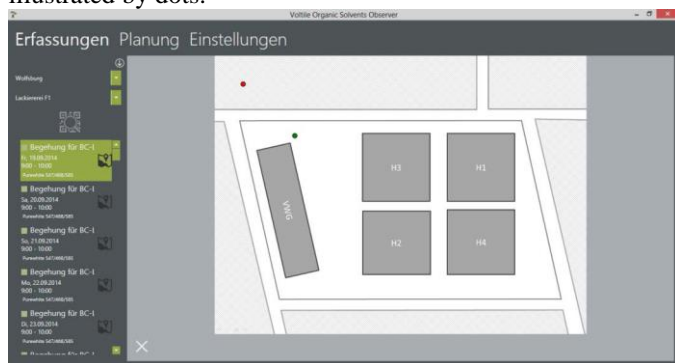


Figure 5 Localisation [1]

Where there are data sources such as paint containers that are often visually indistinguishable from each other, identification functions via QR codes will be implemented. When the corresponding QR code is recognised by the camera, the corresponding input field will be called up so that the associated information can be entered. Alternatively, the corresponding inspection can also be selected manually. Once this input form has been saved the information is sent to the server client and is saved there. [1].

The collected data can then subsequently be processed in the desktop application. Under the "evaluation" tab in the desktop application there are two tabular evaluations and one graphical evaluation (see figure 6). The tables serve as the export data for the Volkswagen AG VOC monitoring tool. The graphical evaluation is only intended to be used to give a quick visual overview of the material consumption ratio. The following figure shows such an overview using example data [1].

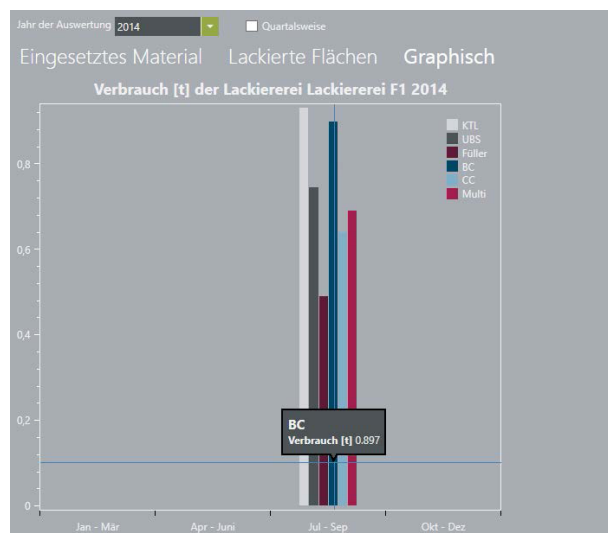


Figure 6 Graphical evaluation [1]

IV. CONCLUSION

A client/server system has emerged that successfully delivers the input data for the monitoring of VOC emissions. The relevant input data for this system will be systematically collected on-site with the assistance of mobile clients, which will guide the collector through a structured work process. The goal of higher usability will be achieved through rapid prototyping. The goal of reducing the amount of time needed for inspections can also be achieved. Furthermore, with these procedures the previously mentioned media discontinuities will be avoided, which will reduce the potential for error during data acquisition.

Overall, it is fair to say that a distributed, mobile support of the data collection for the material flow management at Volkswagen AG represents a promising opportunity to significantly improve the data quality of the relevant material flows and thereby highlight potential economical and ecological savings [1].

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Wattwork

The design of an application for the support of sustainable work practices in offices

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Abstract — This work describes the design process of an eco-feedback system for office workplaces. In a first step, a literature review was done looking at design implications regarding eco-feedback systems for workplaces. We could identify that information transparency is a major issue that has to be taken into account. The information has to be delivered in real-time and the eco-feedback system has to display individual and only relevant information to its users. The literature research lead to a first paper based prototype, which was evaluated by experts to identify problems regarding functionality and usability. Due to the evaluation, we improved the prototype and developed a clickable low fidelity prototype that can be tested by users. Afterwards more interviews have been conducted with office employees to conceive their motivation and gather further requirements. After each interview the clickable prototype was introduced to the employees. The users expressed all their concerns about the presented eco-feedback system, so new requirements could be identified. A major finding was that user have different needs and motivations to use an eco-feedback system. On one hand there were users, who wanted a wide range of information including absolute data. On the other hand, there were users, who criticised the complexity of an application that provides too much information. They postulated an easy application, without any numerical description. As a result, the initial view was minimised, but the user has the possibility to get detailed and customizable information on request. The study was conducted in the context of the project livinglab-energy.de, which is supported by Umweltministerium NRW.

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Keywords — eco feedback, sustainable IT

I. INTRODUCTION

More and more people work in office environments. One out of five persons in Germany has a job in an office, which makes 16.6 million people in sum [1]. Electrical devices are a part of those workplaces and are responsible for 30% of the energy consumption in non-producing business [2].

Since ecological issues are constantly a highly discussed issue, it makes sense to think about a conscious and sustainable use of energy in office workplaces. Regarding this problem, the behaviour of workers using the energy plays a

major role [3]. Energy is an “invisible” resource, which cannot be seen by people like other resources (E.g. water or fuel) [4]. The goal of this work is to design an application that helps workers to develop awareness towards the consumption of energy in the workplace to foster a sustainable use of this valuable resource.

II. METHOD

The design of socio-technical applications requires dealing with potential users [2]. To involve these users, we developed the application using user centered design methods, consisting of the following steps: Understanding the context of use, definition of the requirements, conception and evaluation.

A. Understanding the context of use: Literature research

Initially we reviewed eco-feedback literature to get a broad overview about the state of the art. Our goal was to find design-guidelines of effective eco-feedback systems for workplaces including the common available technologies.

We analysed different studies about the measurement of energy consumption data in work places. The review revealed that savings through eco-feedback technologies are possible and the technology can agitate workers to change behaviours while using energy at work [3]. The use of eco-feedback systems fosters the awareness and has a positive effect on energy savings [5]. There are factors that are important for eco-feedback systems to make savings possible. First, it is important to give transparent and relevant information about the energy consumption to the office worker. The user should be able to relate between the own behaviour and the resulting energy consumption through an adequate visualisation [8]. Real-time feedback supports this and increases the potential savings [6], [7]. It is essential to consider social aspects of the work environment to establish sustainable and enduring improvements. This includes developing an awareness of the workers' perception of the use of energy in the workplace [2].

Comparison in energy use among the office employees were also discussed controversy in the literature. Some workers could imagine using the comparison as a reference for their own consumption, which could help to interpret the energy data. The other workers pointed out, that it is impossible to compare the energy consumption among

employees, since there are different working times and different work assignments [3].

B. First requirements set

We determined the first set of requirements for our prototype using the findings of the literature research focusing on an adequate visualisation of the energy consumption data.

- To keep entry hurdles low and to not disturb the actual work assignments the energy consumption data should be displayed clearly, need-based and comprehensible for everybody [2], [5], [9]. Measures in kWh are not always easy to understand for users [10]. Additional measures in costs e.g., make it easier to understand the amount of used energy motivating the user [9], [11].
- To reveal saving potentials, it is important to create a relation between behaviour and consumed energy [8]. Fine-grained data can support this [3]. Anti-environmental behaviour should be signalised to foster sustainable changes in behaviour [8].
- To support the data interpretation process of the user the application should enable comparison among workers. This will help the user to evaluate the personal energy consumption [3]. Since energy data is not always comparable among employees, it is necessary to put the data into perspective. Nevertheless, privacy should be preserved, allowing the user to decide wherever he or she enables to share the energy consumption data with the co-workers through privacy settings [3].
- Besides the personal energy consumption, the user should be able to see the consumption of the whole department, to establish a collective sense of responsibility regarding the energy consumption of devices, which are commonly used in the office [3], [8].

C. Design of the paper prototype

Using the requirements, we created some sketches that lead to a paper prototype. The prototype builds the basis for further steps in this work (see Fig. 1). The displayed screen consists of four areas: My consumption, History, Comparison and Goals, tips & badges. The user can switch between the personal and the department consumption.

The employee can see the overall consumption of the present time-period in “My consumption”. He or she can choose day, week, month or year as the time-period. Selecting “details”, fine-grained consumption data is shown that displays consumption determined by devices.

The history-section shows energy consumption in a time-based graph. The comparison enables to compare the own energy consumption with co-workers, e.g. with a determined person or the (anonymous) worker with the lowest consumption.

Another feature is “Goals, tips & badges”. The user can set his or her own goals, and earn honour through badges. All the features are also available in the “Department-Mode”.

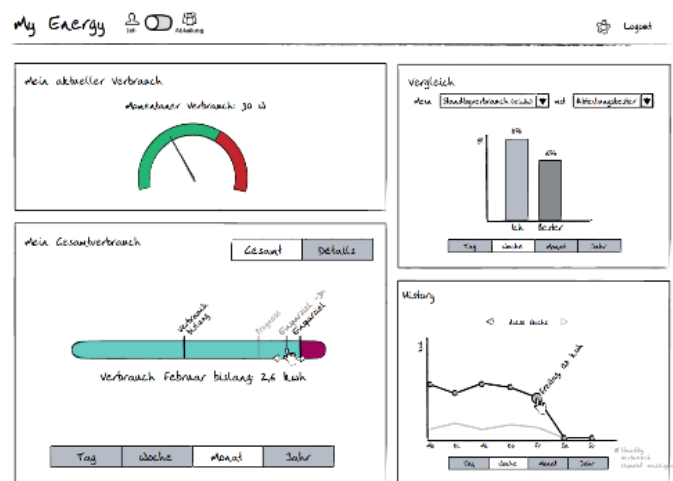


Fig. 1. Paper prototype (see more here: <http://goo.gl/VzqiYh>)

D. Expert evaluation

For further development, the prototype was shown to three experts, to find problems that can lead to less efficiency in energy savings or usability issues.

It was pointed out that the user's focus is disturbed because of the arrangement of the four all same sized window boxes. The focus should be set to the main feature, which is the overall consumption. This could discourage the employee. The application should involve other measures than kWh and costs. It should display metaphors using pictures or colours to make the measures more comprehensive and understandable. This should be used to display low or high energy consumption, since many users cannot handle the unit kWh. It was pointed out that recommendations regarding the behaviour should be inferable for the user to achieve a change: A prediction should be integrated, which indicates the amount of energy that will be consumed in a month if behaviour retained the same. Displaying the wastage through visualisation of energy that used in stand-by mode could also be helpful.

The experts recommended to show a goal in energy savings, which can be adjusted by the employee. Additionally changes in the wording should be done.

The amount of the total energy consumption was criticised. The illustration through a speedometer creates the impression, that it displays a momentary value that can increase or lower any second. The consumption should be displayed in another way, since it is still not possible to compare the data in relative way.

The privacy was rated as well implemented, and very important. However, the usability could be increased by just offering the white list, eliminating the black list. To save privacy at its best, highest privacy settings should be set by default.

E. Second prototype

In the next step we designed a new, clickable prototype as an artefact that can be shown to potential users (s. Fig. 2). We

adjusted the layout to set the focus on the main function. The overall consumption was presented using a bar that included a prediction in energy use. We set a limit into this bar, which can be adjusted with drag n drop gestures. The speedometer was no longer displaying the overall consumption, but the momentary consumption.

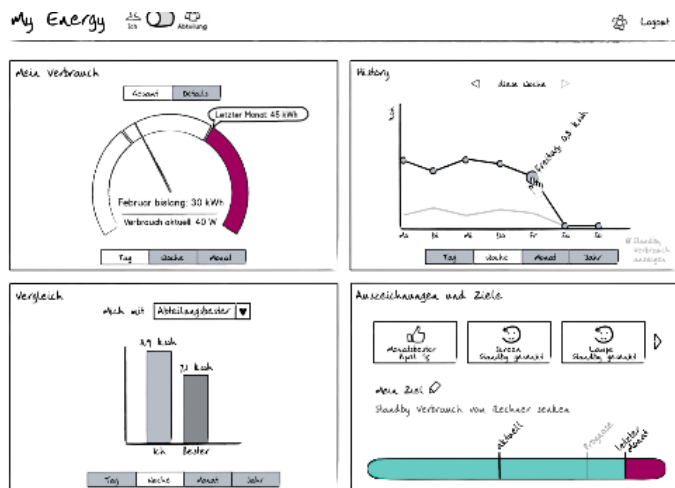


Fig. 2 Clickable Prototype (See everything here: <http://goo.gl/MCPjUS>)

F. Userinterviews & -evaluation

To detect attitudes, sensibility and motivation of office workers towards energy consumption and the use of energy-feedback in the office, we conducted semi-structured interviews. The interviews with the three employees were audio-recorded and transcribed verbatim.

We asked questions about the work practices in the offices, the needs and the requirements of the office workers to involve the findings in our design concept.

After the interview, the clickable prototype was introduced to the employees to find out what should be changed to meet their demands. Additionally, four interviews of a previous study were analysed.

1) Interviews

We asked the employees about their work practices, their attitudes towards energy consumption and requirements for a suitable eco-feedback system.

The provided devices in the offices were quite similar to each other. All the workers pointed out, that high flexibility towards working times characterized their jobs. The companies also offer the possibility to work at home. The hours of labour were not captured. Two co-workers were sharing one office in all the cases.

- In the company there was no possibility to see the own energy consumption. No actions have been done to motivate the employees to save energy.
- Nearly all of the employees were interested to use an eco-feedback system. But it was also pointed out, that there are no incentives given by the company to save energy. It was also said that the amount of energy used by them is irrelevant compared to the overall

consumption of the company. Additionally, the company should involve sustainable thinking in its culture.

- The employees require a system, that is easy to use. The interaction should not require much time.
- The visualisation of the energy consumption data should not overcharge the employees and should be comprehensive.
- The eco-feedback system should reveal potentials in saving.
- The employees pointed out the importance of privacy settings and all of them remarked, that the data could be abused otherwise, since the energy consumption data can indicate, how much time a co-worker spends at work. The data should just serve for a voluntary check on themselves.
- But there were also employees who pointed out, that the comparison allows a better assessment on self performance in energy use boosting the awareness of the own energy consumption.

2) Evaluation

After the interview we conducted an evaluation with the three interview partners. Most of them rated the features of the prototype as useful.

One of them thought, that the system offers too many functions. He asked for a minimalistic application that does not require a high amount of time to use and understand saying: "I want only a bar". He asked for an option to hide all other windows.

All the office workers rated the privacy settings as positive. The comparison was criticised. The different labour hours make it hard to compare the data and can lead to demotivation. Everybody did evaluate the comparison between departments, since the differences regarding team size and devices are too large.

G. Second set of requirements

We used the results of the interviews and the evaluation to create a second set of requirements, which were used to design another prototype.

The visualisation should be adjustable to the personal needs of every user. There should be a minimalistic view and it should be possible to hide all measures. The comparison of departments should be removed. The comparison among employees was kept. It should be up to the users if they want to provide data to their co-workers. The adjustment can be made specific for each co-worker.

Since the visualisation of the momentary energy use was not interesting for most people the speedometer was also removed.

H. High fidelity prototype

The home screen of the application was designed in a minimalistic design. The overall consumption was visualised

through a single bar. Like in the previous versions, the user can switch between personal consumption and department consumption. The additional features (Details, History and Comparison) can be displayed by only one click. The information is still adjustable according to the demand on information of every single user. Like required, the comparison was removed in the view of the department consumption.



Fig. 3 High fidelity prototype (See Video-demonstration in German here: <http://goo.gl/Doq6dA>)

III. CONCLUSION & DISCUSSION

This work examined how to design an eco-feedback system for office workplaces to foster sustainable work practices. The major challenges identified in this study were:

- Simplistic visualisation of the energy consumption data that enables a fast interpretation without disturbance of the actual work assignments
- Saving potentials should be easy to spot
- High customisability to meet everybody's demand on information
- Protection of privacy

All these requirements were considered in the design of our adjustable system. The problems were examined and discussed with the participation of office workers. The customisability involves the privacy settings and the visualisation. The initial view was designed minimalistic, with the option to show relevant information with only one click.

Further studies should examine how office workers would adopt wattwork in their daily work life. Thereby determining whether wattwork will change work practices, towards more sustainable behaviour.

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How to – comprehensively – collect and depict data on conditions for sustainable transport in rural areas?

The approach of the Austrian R&D project “AlltagsSPUREN”*

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Abstract: The Austrian cooperative research project “AlltagsSPUREN“ (loosely translated “everydayTRACES“) aims on developing tools supporting smaller (rural) municipalities in promoting sustainable and active mobility using quantitative and qualitative data gathering methods together with analysis and activation tools. These online and offline based tools will enable to examine the status quo, the demanding situation and the municipal potential regarding sustainable and active mobility. The tools will be tested in selected municipalities. The project focuses especially on encouraging a more active using of sustainable transport modes in everyday life – also taking factors of social inclusion into account. Barriers as well as supporting conditions for walking and cycling and other forms of active mobility are addressed within this project. A special focus is set on the local experience and inclusion of socio-economic groups that are usually marginalized in recent mobility projects. The project addresses local decision-makers and aims to contribute to the pre- and early phase of mobility planning, in order to strengthen knowledge and competence to remove barriers for promoting more sustainable and active mobility. In particular, the project focuses on data provided at local and regional level that can depict mobility conditions comprehensively with minimum effort. Furthermore, it is of interest how this data can be used for reliable scenarios of future mobility demands and determine which strategies can influence this development. The project team covers a broad range of knowledge and skills in the areas of diversity-orientated transport and landscape planning as well as mobility management and environmental informatics. This paper gives an insight in the first preliminary results.

Keywords: sustainable and inclusive mobility, active transport modes, rural areas, webbased ICT tool, traffic and mobility model, municipalities

I. INTRODUCTION (*HEADING 1*)

A. *Status quo: Specific needs of different socioeconomic groups and awareness for sustainable modes of transport*

Active modes of transport, such as walking and cycling, exhibit a wide range of ecological, economic and social benefits for individuals as well as for societies. Therefore, they are more sustainable modes of transport than motorized individual traffic (e.g. private car). Also the provision of public transport is an aspect leading to more sustainable mobility conditions, empowerment and social inclusion, especially for people with physical limitations, young people and elderly people. [10, 11]

Particularly, people with care-giving responsibilities, children and elderly people have a need for diverse mobility alternatives which consider their specific set of resources (time, money, abilities etc.). The choice of transport modes differs between people with care responsibilities and not-caregiving people. Currently, especially in rural areas, care-givers and people in care feel often more dependent on car transport, often by others, on their everyday trips, as they are not aware of alternatives or alternatives are in fact missing. [1] Traditional

* The project is funded by the Austrian Research Promotion Agency (FFG) and the Federal Ministry of Transport, Innovation and Technology (BMVIT).

transportation planning approaches strengthen this feeling of car-dependency by setting a strong focus on motorized individual traffic.

However, the promotion of active and sustainable modes of transport may enable these socio-economic groups to handle their mobility needs more independently and save their resources (e.g. children can go to school by themselves and do not need to be accompanied by their parents). Accompanying trips therefore may be minimized if awareness for sustainable modes of transport is raised. [11] Research on exclusion is still rare and hardly included in mobility projects. If it is included, it is often limited to physical disabilities. [2] Other excluding aspects related to socio-economic circumstances and access to resources, for example care-giving responsibilities, are neglected.

The level of awareness for different modes of transport and types of trips varies in transport planning. Common travel surveys in Austria, for example, do not adequately examine short trips or complex trip patterns. Short trips on foot remain underrepresented due to their low rate of reporting. As a result, these surveys often confirm local decision makers in their point of view that "walking" is not fully worth considering and is not valued as an equitable mode of transportation. Consequently, transport-planning decisions are mainly based on data that tend to take into account walking inadequately [5, 9].

B. *Status quo: Rural areas and their special challenges*

Statistical data show that in the year 2014 2,278 municipalities in Austria have less than 10,000 inhabitants. Altogether they account for 4.6 million inhabitants or over 50% of the total population in Austria (total population: 8.5 million). [8]

These mainly peripheral and rural municipalities face special challenges and problems in the contexts of transportation, mobility and provision of public services and basic supply. Additionally, in the last decades public transport systems have been reduced in a considerable way. There is also a strong tendency of centralization of jobs and supply infrastructure. As transport infrastructure for cycling and walking is hardly developed in a sufficient way, many inhabitants of the communities face a feeling of car-dependency. [12] This aspect is strengthened by the fact, that the terrain in some part of Austria is partly very steep and difficult to access.

Demographic change is another aspect, which has to be considered in decision-making and transport planning processes. By the year 2030, 24% of the total population in Austria will be older than 65 years. That is an increase of 6 percentage points compared to the year 2012. In rural areas the proportion of elderly people will be even higher. [7] As demographic change affects especially peripheral and structurally weak regions, opportunities have to be found to guarantee independent mobility for the elderly and their participation to social, cultural, political and economic life.

C. *Status quo: Lack of comprehensive approaches*

Active forms of mobility ("mobility out of personal embodied resources" i.e. walking and cycling) were the dominant modes in the last centuries. In the last decades, though, they have become less important, due to societal and structural changes. These changes are constitutive for life circumstances, which trigger mobility behaviors. However, the lack of active mobility in our daily life has not only a negative impact on health and environment but also on our identification with our social environment and thus the social cohesion of a municipality. [4] In order to reach the goal of a more sustainable mobility of the inhabitants of communities, new ways and comprehensive methods have to be developed.

Although there are already some initiatives and networks in Austria, which provide support for the municipalities in their transport planning activities, few comprehensive approaches can be identified. There are initiatives, which support the municipalities in isolated situations (e.g. improving way to school for children, promoting investments in bicycle infrastructure, etc.). Moreover, tools are available to conduct analysis and planning activities. Currently, tools for sustainable mobility are mostly focused on:

- Mobility planning
- Simulation of traffic flows
- Estimation of effects of measures
- Calculation of traffic emissions and follow-up costs
- Accounting systems for mobility

Within the scope of the EU-project PROSPECTS, an easy to understand handbook for sustainable transport was developed for decision makers, which is also available in German language. Moreover, a web-based database (KonSULT) was created, giving examples for possible activities for sustainable land use and transport. However, this database is available only in English language and is addressing urban transport planning. Moreover, a comprehensive analysis of the status quo in the municipalities not included. [3]

However, these tools are quite complex and mainly address consultants, planners and scientists, but not decision makers in communities and municipalities. (Nota bene: In Austria municipalities are in charge of most of transport planning responsibilities.) In most cases comprehensive analysis approaches including socioeconomic parameters are not included.

II. THE AUSTRIAN R&D-PROJECT "EVERYDAYTRACES"*

A. *Aim*

The overall aim of the project "AlltagsSPUREN" is to develop a set of web-based ICT analysis and activation tools that comprehensively assists rural municipalities by fostering active and sustainable mobility, which primarily means to foster environmental friendly, socially acceptable and resource-sensitive forms of mobility. These tools shall promote active

and sustainable transport modes in everyday life in cooperation with municipalities of up to 10,000 inhabitants. Thereby socio-economic groups, which are usually neglected in traditional traffic and mobility planning methods and mobility projects, such as patchwork-households, people with caring duties or unemployed young people, will be particularly addressed in order to raise awareness for their mobility needs and avoid further exclusion during planning processes.

B. Planned project outputs

The tools under development consist of three parts, which are, as follows:

(1) A freely accessible, interactive web-based platform aiming on raising awareness for sustainable mobility among the municipalities' population and encourage joint measures to foster sustainable mobility in the municipality. It allows citizens to report their experience with active transport modes in their municipality. This tool does not aim on purely mark neuralgic points, but encourages the users to tell their private mobility stories. This helps politicians and planners to create a mobility futures connected to the experiences from the past.

(2) A digital analysis tool for municipalities' politicians and local authorities, to comprehensively conceive the status-quo of mobility characteristics and framework conditions of active and sustainable modes of transport within the municipal area, taking into account various socio-economic aspects of population. A check of the relevant framework conditions in favor or limiting sustainable mobility is made based on data from public statistic and information provided by the municipality. The tool allows to identify the needs for improvement as well as potentials at a glance and thus helps policy makers and planers to develop problem-centered mobility solutions. For this purpose, algorithms were developed based on scientific findings. The tool depicts mobility conditions comprehensively with minimum effort.

(3) A digital scenario tool for developing scenarios and derive directions of actions regarding the achievement of targets towards more sustainable mobility within the municipality. The expected impacts of planning activities are depicted in a qualitative manner by showing how they affect the mobility opportunities of certain groups with specific life circumstance, such as full-time employed single parents, unemployed youths, people in patch-work families with two households etc.

The analysis and scenario tool introduces novelties in two ways: Firstly, it tries to develop a system that helps municipalities to identify measures that improve the situation for different groups of people. Secondly, it explicitly intends to address municipal decision makers instead of focusing on consultants, planners and scientists. Additionally to the development of the tools, a series of workshops is developed in order to support the municipalities in developing mobility visions and designing approaches to reach them.

C. Methods

Within the project, quantitative and qualitative methods of collecting and analyzing data as well as participatory and

interactive methods are used. This includes an interactive website (www.alltagsspuren.at) to share and spread people's experiences with active and sustainable modes of transport, which already has been established as part of the project.

Locally qualitative data will be gathered by using the method of social environment analysis. This method includes walks through the municipality in order to analyze spatial and infrastructural conditions as well as vegetation and landscapes, observations or walks and interviews with citizens.

According the inclusive approach of the project the local data will be reflected with respect to type-descriptions mirroring diverse life-circumstances (e.g. full-time employed single parents or unemployed youths). This should on the one hand raise awareness for certain mobility needs within the municipalities and should, on the other hand, guide planning processes towards inclusion.

D. Project team

The project team covers a broad range of knowledge and skills in the areas of gender- and diversity-orientated transport and landscape planning as well as mobility management. The following SMEs and universities are part of the consortium: Büro für nachhaltige Kompetenz (Consultancy for Sustainable Competence) B-NK GmbH (gender and diversity expertise in planning and research), akaryon GmbH (environmental informatics), Dr. Roswitha Hofmann – uebergrenzendenken – Forschung & wissenschaftliche Beratung e.U. (social sciences, diversity expertise), Dipl.-Ing. Ralf Dopheide e.U. (coordination of local activities), Institute for Transport Studies of the University of Natural Resources and Life Sciences Vienna and Institute of Transportation, University of Technology Vienna – both as scientific partners.

Amongst other tasks, the interdisciplinary team carrying out the project is assessing the various data provided at the local and regional level that can depict mobility conditions for municipalities comprehensively with minimum effort. Moreover, the project team will be present in the municipalities during the pilot phase, working directly with decision makers and inhabitants to optimize the tools to be developed.

III. PARTICIPATORY APPROACH

Rather than using a top down approach, the project fosters active participation by integrating the knowledge and experiences of the local population into analysis and project planning. The process components are laid out in a manner that allows, in addition to a thorough analysis, raising the awareness and competence of the inhabitants as well as the political and institutional representatives and decision makers of rural municipalities. Thus they encourage higher participation rates in order to achieve sustainable mobility targets. In co-operation with pre-selected municipalities, the prevailing mobility conditions as well as key indicators, including those measures that support walking and other active modes of mobility have been researched and a web based analyzing- and planning-tool has been developed. For municipalities, the tool offers the possibility to depict local and regional mobility conditions in a comprehensive way. Based on these specific conditions, the

tool provides concrete guidelines on action to be taken by decision-makers to foster sustainable mobility.

A. Participating municipalities

In order to test the tools developed in the project, a pilot phase has been initiated. Participating municipalities will provide input and feedback to the analyzing tool and especially to the availability of the data required. Moreover, activities (workshops, walks, etc.) in the municipal area will be conducted by the project team, to activate and inform the inhabitants. In the selection of the municipalities consideration is given to a variation of number of inhabitants and environmental conditions.

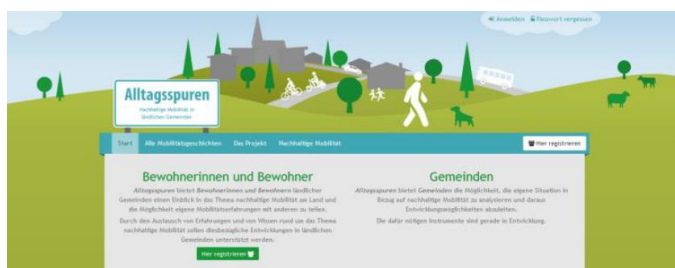
The following Austrian municipalities take part in the pilot phase.

- St. Veit im Defereggental, The Tyrol: 707 people live in St. Veit im Defereggental. The municipal area is situated in a mountain valley and is therefore to be characterized as peripheral. Conditions for walking and cycling are challenging, as the terrain is partly very steep.
- Hollabrunn, Lower Austria: 6.836 people live in the city of Hollabrunn. The municipal area is 50 kilometers away from Vienna. The landscape is predominantly characterized by flat terrain. Proposition of basic supply is relatively well. [6]

B. Activation via website www.alltagsspuren.at

As one approach to encourage participation among the local communities as well as their citizens, an interactive webpage was launched. This activation module should initiate communication and activation processes within the municipalities among their inhabitants and between citizens of different municipalities.

Fig.1: Screenshot www.alltagsspuren.at (B-NK & project team)



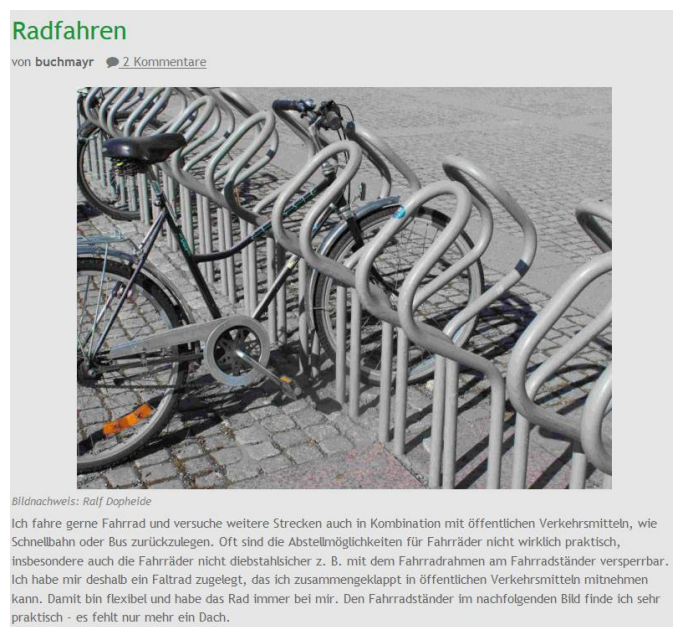
The website provides following features:

- Information about the project and various facts about sustainable modes of transport (e.g. statistics about trip lengths and purposes, political framework and stakeholders in Austria, forms of participation applicable in rural areas);
- The website also provides basic information on the topic of sustainable mobility in rural areas.

- A service section for inhabitants (also initiatives, clubs etc.) of municipalities, where individual stories dealing with sustainable and active mobility and transport modes can be provided (for other inhabitants and decisions makers);
- A digital analysis tool for politicians and local authorities (work in progress);
- A digital scenario tool for politicians and local authorities (work in progress).

The website offers the possibility to provide individual stories dealing with sustainable and active mobility and transport modes. This can be seen as a contribution to the specific local history and helps to visualize knowledge and experience of the “local crowd”.

Fig. 2: Screenshot www.alltagsspuren.at, story written by a user (B-NK & project team)



C. Activities during the field work

Following activities will be conducted in the municipalities during the pilot phase:

- Social environment analysis;
- Workshops conducted at schools with focus on sustainable mobility;
- Walk-Shop in the municipal area with interested residents and stakeholders;
- Information and awareness-raising evening event for residents about sustainable mobility.

More activities will be designed in further project work.

IV. DIGITAL WEB-TOOL – ANALYSIS AND SCENARIOS

The digital analysis tool (work in progress) is used to identify and assess the framework conditions for sustainable

mobility within the municipalities. The tool gains its data on both, data from public statistics and data provided by the municipalities. For this purpose, the analysis tool includes a frame where data can be filled in by the administrative staff and analysis outputs can be illustrated.

The dataset includes quantitative variables such as the number of inhabitants, the share of pupils visiting a local school or the number of days with snow cover as well as qualitative variables such as the perceived affinity of the citizens for specific transport modes. The variables are summarized to 36 indicators which are grouped into six categories which are “population”, “spatial patterns and settlement structure”, “transport infrastructure”, “individual mobility: affinity and access to transport modes”, “nature” and “commitment of the municipality to sustainability”. “Spatial patterns and settlement structure” includes e.g. the indicators “population density”, “commuter destinations” as well as the number of shops, facilities for recreation, education or health care.

There are two kinds of indicators: absolute and relative ones. Absolute indicators means that certain facilities are counted to an absolute value such as the number of pubs, restaurants, discos or other leisure facilities within the municipality. Relative indicators are compared with the indicators values of other municipalities. One example is the indicator “share of children below six years” for which the quantiles of reference municipalities are calculated and the municipality at hand is assigned to the quantile it refers to. For both, absolute and relative indicators, the impact of a certain indicator value on the different transport modes is analyzed. The mean is calculated for all indicators belonging to a category.

Within the project, the team has developed some new indicators and innovative key figures, for instance an “indicator for hilliness”, which considers topographical conditions. Further criteria such as quality of paths in terms of constructional design as well as surface types, accessibility to quality of public transport and sidewalk kilometers are also incorporated in the web-tool. Such – new – data did not evolve from mobility surveys. Nonetheless, this data is crucial for comprehensively depicting mobility conditions and can easily be provided by cities and communities. These key figures are used for both, the analyzing tool and the scenario tool. As a further analysis step this figures will be transferred to the view of mobility demands of different groups of persons (e.g. 16 year old pupil, living at home; active senior citizen etc.).

The digital scenario tool (work in progress) is put on top of the analysis tool. A list of measures will be developed, each measure changing the influencing factors for the means of transport and indirectly also changing the situation for each group of people.

At the current stage of the project the requested data is accessible through an excel-based document. The municipalities are requested to give feedback about availability of data. This data framework will be integrated, after the feedback phase, on the website.

Fig. 3: Screenshot excel-based feedback document for local authorities (B-NK & project team)

	Einheit	Eingabewert für Ihre Gemeinde	essentielle Daten nicht verfügbar (ja = x)	Daten schwer zu ermitteln (ja = x)
Bevölkerung				
mit Hauptwohnsitz gemeldet	Anzahl Personen			
Kindergartenkinder/ Hortkinder	Anzahl Personen			
Kindergartenkinder/ Hortkinder (Männlich)	Anzahl Personen			
Kindergartenkinder/ Hortkinder (Weiblich)	Anzahl Personen			
Zu pflegende Personen (Männlich)	Anzahl Personen			
Zu pflegende Personen (Weiblich)	Anzahl Personen			
Prognose der Bevölkerungsentwicklung bis 2030				
Bevölkerung wird stark schrumpfen (<-9%)	Ja/Nein			
Bevölkerung wird schrumpfen (-9%)	Ja/Nein			
Bevölkerung wird stagnierend (-3% bis +3%)	Ja/Nein			
Bevölkerung wird wachsend (+3,1 bis +9 %)	Ja/Nein			
Bevölkerung wird stark wachsend (>+9 %)	Ja/Nein			
Menschen mit Behinderungen				
Gehörbehinderung	Anzahl Personen			
Sehbehinderung	Anzahl Personen			
Gehirnbehinderung	Anzahl Personen			
Raum- und Siedlungsstruktur, Infrastruktur, zentralörtliche Einrichtungen				
Gebietsfläche	Fläche in km ²			
Siedlungsfläche (Bauland nach Flächennutzungsplan)	Fläche in km ²		x	
Fläche Dauersiedlungsraum (Bauland, Verkehrsfläche und Landw. Nutzfläche)	Fläche in km ²		x	
Siedlungs- und Zentrenform				
Gemeinde mit mehreren Ortschaften mit einem gemeinsamen	Ja/Nein		x	
Gemeinde mit mehreren Ortschaften mit jeweils eigenem Geschäftszentrum	Ja/Nein		x	
Gemeinde mit mehreren Ortschaften ohne Geschäftszentrum	Ja/Nein		x	
Solitäre Gemeinde (nur eine Ortschaft) ohne Geschäftszentrum	Ja/Nein		x	
Solitäre Gemeinde (nur eine Ortschaft) mit mindestens einem	Ja/Nein		x	
Versorgungs- oder Geschäftszentren in der Gemeinde	Anzahl			
Gebäude in der Gemeinde	Anzahl		x	

As a result, the tools will be tailor-made for the purposes, capabilities and needs of municipalities. The algorithms used in the web-tool, produce results which illustrate different realities of various socio-economic groups within the community.

V. EXPECTED RESULTS

In future, the web based analyzing- and planning-tool, which is developed and tested within the project “AlltagsSPUREN“ will be available as a service for all Austrian municipalities. The tool allows combining, displaying and comparing data on local and regional conditions on the one hand, and providing detailed data on active sustainable mobility on the other hand. Thus the tool supports municipalities to carry out an in-depth analysis of their walking conditions on a local level as well as to derive directions for implementing more active and sustainable forms of mobility.

This project offers a tool for decision-makers in municipalities, who want to develop mid- and long-term innovative solutions in the area of active mobility and the relevant change processes, a form of optimized support with the aid of ICT tools.

VI. OUTLOOK

The project started in October 2014 and will be completed in September 2016. The interactive, web-based platform for the activation of the municipalities’ population has already been established. Currently, we are working on the analyzing tool, which will be tested in two Austrian municipalities over the next few months.

At the conference in September 2015 we will present the participatory approach of the project as well as the already finalized web-platform and a draft version of the digital analyzing tool.

ABOUT THE AUTHORS

Dipl.-Ing. Dr. Bente Knoll works as a self-employed landscape and transport planner, consultant and social media designer. The focus of her professional work as managing director of Büro für nachhaltige Kompetenz (Consultancy for Sustainable Competence) B-NK GmbH is to integrate gender

and diversity perspectives in urban and transport planning, architecture and mobility. Bente Knoll also holds various teaching assignments at Austrian universities in the field of Gender Studies and Engineering.

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Dipl.-Ing. Petra Busswald, holds a degree in 'technical mathematics' and 'technical protection of the environment' from the University of Technology in Graz / Austria. After several years in university projects and at an environmental software company, in 1999 she founded the SME akaryon together with Franz Niederl. akaryon specializes in environmental informatics projects (energy simulation tools, carbon calculators etc.) integrating quantitative sustainability assessment methods in tools for diverse target groups.

Dr. Roswitha Hofmann is sociologist and lecturer at the WU Vienna and the University of Applied Sciences Wiener Neustadt. Her research focus is on diversity and inclusion issues in organizations and sustainability under diversity perspective. She has conducted field studies in Austria and internationally. She has published a number of articles in peer reviewed journals as well as in applied media and edited books. Since 2011 Roswitha Hofmann has been owner of „uebergrenzendenken“ – Forschung & wissenschaftliche Beratung e.U.

Dipl.-Ing, Dipl-Georg. Christoph Link works as a researcher at the Institute for Transport Studies, University of Natural Resources and Life Science, Vienna, Austria. He works in several projects in the field of mobility behavior. His tasks include data collection, data analysis and model development.

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ICT systems supporting sustainable operation and development of municipal waterworks

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Abstract—In the paper a concept of an ICT system for complex management of whole communal waterworks is presented. The ICT system called MOSKAN consists of several program modules integrated by a GIS platform. The system is being developed by the Systems Research Institute (IBS PAN) in Warsaw and partially tested in some Polish waterworks.

Keywords—waterworks management, computer aided decisions making systems, mathematical modelling and optimization)

I. INTRODUCTION

Communal waterworks usually consist of four independently working subsystems: pumping unit and a water clarification plant, water distribution network, wastewater network and finally a wastewater treatment plant. A computer aided support of a waterworks is commonly related to independent support of the above listed subsystems. The main difficulties might lie in technical development: separate computer programs are bought for these subsystems. It results in overlapping many operational tasks by different enterprise divisions. This type of approach might lead also to so called “information chaos” which in fact makes the management of the company more complex. Hence, the management team of the waterworks are discouraged to invest in modern, innovative IT systems. Moreover, the capabilities of integration of different programs distributed by different vendors are difficult and time consuming.

On the other hand, the real structure of the waterworks consists of the in rows structure of the above listed subsystems and should be reflected in an IT software which supports as a composite unity the water company. Unfortunately this type of management is commonly not implemented. Hence it is crucial to develop integrated ICT systems taking into account a holistic view of the waterworks and corresponding technological processes. The implementation of such the systems in waterworks secures their sustainable operation and development and such the kind of operation could be called as waterworks smart management. Such systems are under development in System Research Institute (IBS PAN) for over 15 years.

In this article the design of the last, most advanced ICT system called MOSKAN will be presented. Furthermore the main use cases, functions and capabilities of the MOSKAN will be described. Currently the ICT system supports the management of the following working subsystems: pumping unit and water clarification plant, water distribution network

and wastewater network. The results of implementation of the system in some Polish waterworks will be also discussed.

II. THE MAIN COMPONENTS OF THE ICT SYSTEM FOR WATERWORKS MANAGEMENT

According to the mentioned idea in development of integrated ICT systems a concept of a system for joined solution of many management tasks in waterworks scale has been developed at IBS PAN (Fig. 1).

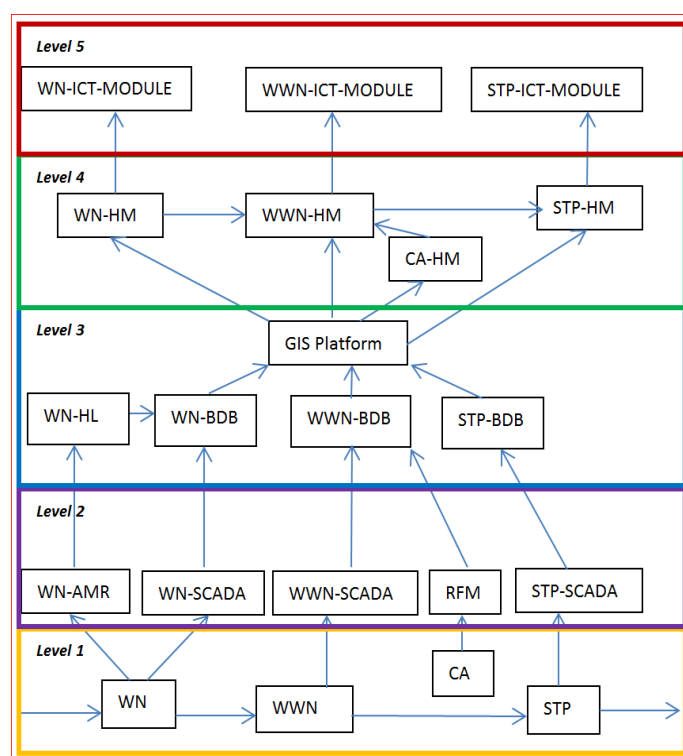


Figure 1. Block diagram of the ICT system for smart management of a waterworks; WN – WaterNet, WWN – WasteWaterNet, CA – CatchmentArea, STP – SewageTreatmentPlant, AMR – Automatic Meter Reading, RFM – RainFallMonitoring, HL – HydraulicLoad, HM – HydraulicModel.

In this system 5 structural levels consisting of 4 waterworks objects and several program modules are foreseen and the key module of the system is the GIS platform with its central data base divided into 4 object oriented branch data bases (BDB). The waterworks objects located on the *Level 1* of the ICT system are Water Network (WN), Waste Water

Network (WWN), Water Catchment Area (CA) on which the waste water network is located and Sewage Treatment Plant (STP). On *Level 2* the programs of monitoring of water net (WN-SCADA and WN-AMR), wastewater net (WWN-SCADA), catchment area (RFM) and the sewage treatment plant (STP-SCADA) are collected. These programs are *on line* measuring and recording in their data bases the data concerning the water production and selling, water flows and pressures in the water net, rain falls, canal filling heights and sewage flows in the wastewater net and the raw sewage inflow to as well as clarified sewage outflow from the sewage treatment plant. These data are exported to the GIS branch data bases which are parts of the central data base of the GIS system situated on *Level 3* of the ICT system. There from all the data some special data tables are prepared including the information enabling hydraulic modelling of the waterworks objects and in form of so called *views* they are transferred to *Level 4* where the programs for modelling the water net, wastewater net, catchment area and the sewage treatment plant are assembled. On *Level 5* are the programs solving the waterworks management tasks with the use of algorithms of approximation, mathematical modelling and optimization. In this way each level of the ICT system is a kind of data source for the successive level programs and the programs of the last *Level 5* are these ones which realize the actual computer support for the water works management. These programs are collected in 3 computing modules dedicated for water net (WN-ICT-MODULE), waste water net (WWN-ICT-MODULE) and sewage treatment plant (STP-ICT-MODULE) (Fig. 1).

Each computing module of the ICT system is autonomous and can run independently from each other but at the same time all modules cooperate via their hydraulic models with the GIS system using for their runs the data gained from the GIS central data base. Each module and also each hydraulic model has got its own interface and its own database and these bases exchange the data with the GIS data base or with each other via SQL tables. In the following the short descriptions of the system modules are given [4, 5, 7, 9].

Water Net ICT Module

The ICT Module for water net developed in IBS PAN is most extensive and best tested in the practice in several Polish waterworks. Its structure and functionality is shown in Figure 2. It consists currently of ca. 20 programs realizing the main water net management tasks by means of algorithms of multi objects optimization, kriging approximation and mathematical modelling. These tasks are for example [8]: water net hydraulic optimization when with the exchange of some selected pipes the water pressure is regulated on the end user nodes of the network; energy saving pumps control in the pump works located at the network and serving for supplying it with the water or for raising the pressure inside the net; planning the water net revitalization what means the selection of pipes to be repaired or exchanged because of the risk of their failure; planning the network extension in case of a city development or of attaching some neighbour nets to the municipal one; valves control for raising the water flow

velocities and improving as the result the water quality; detection and localization of the hidden water leaks to eliminate or reduce the water losses resulted from the leaks.

To realise these tasks a water net hydraulic model correctly calibrated and also a SCADA system appropriately planned have to be available. Because of that also some programs for calibration or temporal recalibration of the water net hydraulic model and for relevant planning of SCADA system are included into the ICT Module.

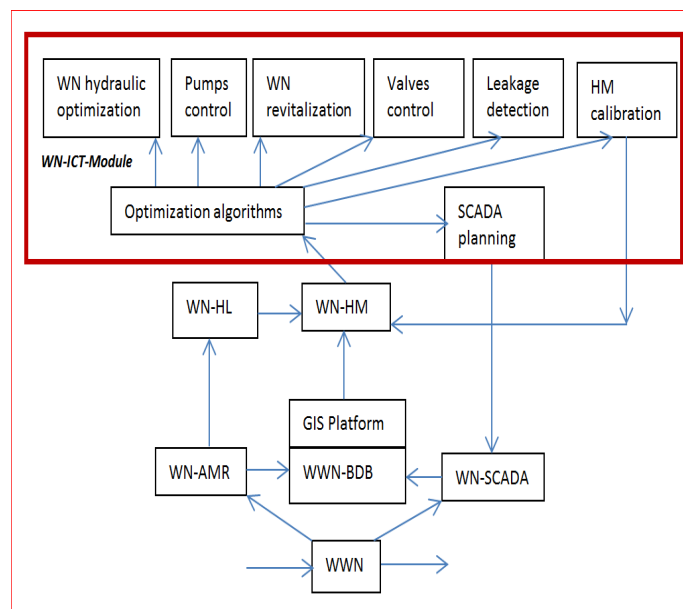


Figure 2. Structure and functionality of the WN-ICT Module.

More detailed descriptions of the algorithms used in the ICT Module and of their ideas are in [2] regarding the planning of the water net revitalization, in [6] regarding the SCADA planning, in [10] regarding the localization of hidden water leaks and in [12] regarding the pumps control. For water leaks detection the neuronal nets and for multi objects optimization some heuristic and genetic algorithms are applied.

A preliminary version of the Water Net ICT Module has been presented in [9] and a possibility to use it as one of the main modules of an ICT system planned for smart city management of a Polish city was discussed in [1].

Wastewater Net ICT Module

The ICT module for wastewater net is sparser in its functionality and also less tested in the practice than the Water Net ICT Module. The ground for it is that the modelling and optimization of communal sewage networks are more complex and complicated than in case of water nets and especially the development of wastewater net models is a very difficult problem. By a water net only 1 hydraulic model of the object is to formulate and calibrate and it consists of relatively simple linear and nonlinear algebraic equations. Contrary to this by a wastewater net 3 different models are to develop and they are the hydraulic of the network, the model of the catchment area on which the wastewater net is located and some rain fall models that generate beside the communal sewage the

additional wastewater inputs to the net. Also the hydraulic model of the wastewater net is much more complicated than a water net model for it consists of partial difference equations more complex by their solution and more time consuming by their calculation than the algebraic relations. Because of that also the implementation of wastewater net models in the waterworks is very rare and hardly to notice in their operational practice.

The structure and functionality of the ICT Module for wastewater net developed in IBS PAN is shown in Fig. 3. It consists currently of 4 programs realizing the main wastewater net management tasks by means of algorithms of multi objects optimization, mathematical modelling and fuzzy sets. These tasks are [4]: wastewater net hydraulic optimization when with the exchange of appropriate canals their filling with the sewage is regulated; planning the wastewater net revitalization what means the selection of canals to be repaired or exchanged because of the risk of their failure; planning the network extension in case of a city development or of attaching some neighbour nets to the municipal one. To realise these tasks a wastewater net hydraulic model correctly calibrated and also the catchment area model and the rain fall models have to be available. Because of that also some programs for calibration or temporal recalibration of the wastewater net hydraulic model and for making automatically the reliable models of the catchment and rain falls are included into the ICT Module.

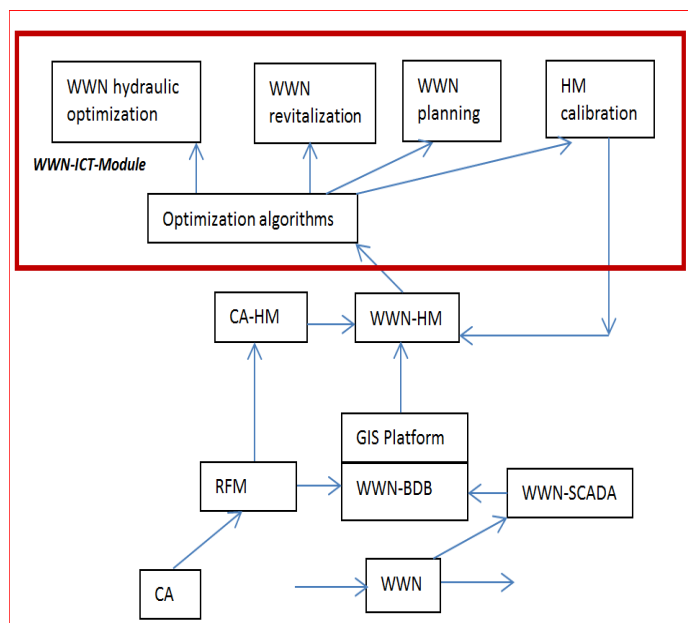


Figure 3. Structure and functionality of the WWN-ICT Module.

More detailed descriptions of the algorithms used in the ICT Module and of their ideas are in [5] regarding the planning of the wastewater net revitalization and in [4, 11] regarding the wastewater net hydraulic optimization and planning and the calibration and temporal recalibration of the network hydraulic model. For wastewater net revitalization the fuzzy sets algorithms and for multi objects optimization the heuristic and genetic algorithms are applied. The results of

testing a preliminary version of the Waste Water Net ICT Module has been described in [11] and a possibility to use it as one of the main modules of an ICT system planned for smart city management of a Polish city was discussed in [1].

Sewage Treatment Plant ICT Module

The ICT Module for sewage treatment plant is currently least worked out and it consists of smallest number of the programs included. The reason for it is the most complicated mathematical description of the object in comparison with other objects of the waterworks. In the sewage treatment plant model beside the object hydraulics also the biological and chemical processes occurring in the biomass flowing through the plant tanks have to be considered. Bacteria and microorganisms creating the biomass are responsible for reducing the sewage pollution and the modelling of these processes described by means of ordinary difference equations and afterwards the calibration of the model including hundreds of unknown parameters is a really hard task. The model including in its structure the object hydraulics and the biomass processes is called as the physical model. By the calibration of this model many calculation runs must be done and in case of the model consisting of hundreds differential equations this process is very time consuming.

To go around this problem an operational model of the plant in form of neuronal nets is formulated and this model that is rapider regarding the computing time serves for modelling the physical model that models the real object. In this way the sewage treatment plant modelling occurs in two phases and the operational model is used for elaborating the object control algorithms which are then tested by simulation runs of the physical model.

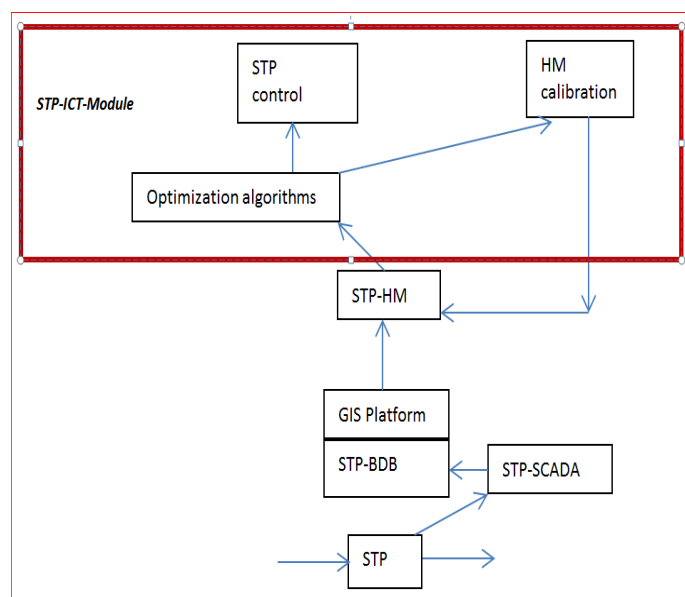


Figure 4. Structure and functionality of the STP-ICT Module.

The structure and functionality of the ICT Module for sewage treatment plant developed in IBS PAN is shown in Figure 4. It consists currently of 2 programs realizing the main wastewater net management tasks by means of algorithms of

multi objects optimization neuronal nets. These tasks are [7]: development of control algorithms regulating the rates of recirculation flows of biomass between the tanks from which the object is consisted; calibration and temporal recalibration of the physical and operational models of the plant. The physical model consists of separated models which are connected in rows and that describe the individual tanks of the whole object and which are: primary clarifiers reducing the organic components from the sewage; activated sludge basins in which nitrogen and phosphor pollution are reduced by the bacteria being in the biomass; secondary clarifiers where the sludge is separated from the treated sewage by means of gravitational settling of the sludge particles. The calibration of the physical models consist then in successively followed calibration of each of these individual models. In case of the operational model it describes the object as a whole and also its calibration is a one-off process.

The results of testing a preliminary version of the Sewage Treatment Plant ICT Module has been described in [7] and a possibility to use it as one of the main modules of an ICT system planned for smart city management of a Polish city was discussed in [1].

Waterworks Management

In frame of the smart and sustainable management of waterworks an integrated ICT system supporting the solution of many management tasks has been developed in IBS PAN and partially implemented and tested in several Polish waterworks. In this ICT system the computer aided management of the water network, wastewater network and the sewage treatment plant basing on the hydraulic models of the objects investigated and on some algorithms of optimization and mathematical modelling is realized. To do it the monitoring systems supervising the water and wastewater nets and the sewage treatment plant must be implemented in the waterworks and with the hydraulic models and optimization algorithms together they are integrated with the GIS system being the computing platform for all programs and forming in this way an united ICT system.

An IT system for computer aided management of communal water networks by means of GIS, SCADA, mathematical models and optimization algorithms has been already presented on the ICT4S'2013 in Zurich [9]. In the ICT system for the management of the whole waterworks the IT system developed for water nets has been extended about new systems dedicated for the wastewater network and sewage treatment plant. These three IT systems are internal integrated based on the data base communication via SQL tables.

The main goals of the ICT system proposed and already constructed are minimization of the operational costs of the whole enterprise and securing the accident-less functioning of its key objects. Some other main goals that are to be achieved with the ICT system are the improvement of the quality of the drink water produced by the water network, generation of scenarios of planning the water and wastewater nets revitalization, control of pump works installed in the water net, hydraulic optimization of water and wastewater nets, reducing the water losses by the early detection and

localization of the hidden water leaks in the water net and the environment protection by minimizing the amount of pollutions introduced to the city river by the sewage treatment plant. The innovation features of the ICT system developed are the integration of all programs supporting the waterworks management in form of an united and centrally operated system, the simultaneous management of all objects being the elements of the waterworks and the use of mathematical algorithms of optimization and modelling for the solution of all management tasks.

The integration between individual modules of the ICT system is implemented on the database level which means sharing the information (tables, views) directly between specialized local databases. E.g. the database of the water network module will read the data describing the network and its parameters from surveying GIS branch database and after this transfer the module programs will use the data for water net hydraulic calculation or optimization. That approach makes modules communication simple, reliable and seamless executable. This is in contrary to the currently practice of waterworks management when the enterprise objects are operated separately with the use of several programs running autonomously and without any cooperation. As a result the quality of the management of different enterprise objects and either their development and modernization is also unlike and very differentiating. The development and introducing into practice of the ICT system described can secure the sustainable development of the waterworks as well as their smart management.

In the following two examples of implementation of the ICT systems in a water network and wastewater network in Poland still as separated and not integrated systems are presented.

III. CASE STUDIES OF IMPLEMENTATION OF ICT SYSTEMS

ICT for water networks

Software MOSKAN dedicated only for communal water nets has been implemented in the Polish waterworks in Mikołów being the city with the population of 40.000 inhabitants. The network investigated is of the length of 310 km with the number of the end users equal to 7.600 objects and with the daily water production equal to 7.500 m³. The hydraulic graph of the network exported by a GIS system to the hydraulic model consists of ca. 3.500 pipes and 3.500 nodes (Fig. 5).

On the water net a SCADA system consisting of 100 measuring instruments for water pressure and of 50 instruments for water flow is installed. The water sale is measured by an AMR system and the data are sending on line via radio transmission to SQL database of the monitoring system. From there they are imported by the GIS system and prepared as input data for the hydraulic model. To the AMR system all end users of the water net are attached. In this way the calibration of the water net hydraulic model can be done automatically and for the data concerning the water selling and water production in form of hourly curves with the time horizon of 24 hours. In

Fig. 6 the localization of the monitoring points for flow and pressure measurements on the water net is shown.

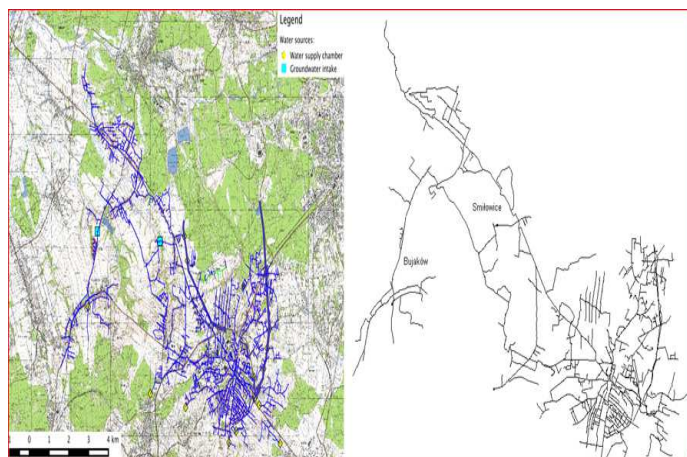


Figure 5. Water network investigated on the geodesy card (left) and as graph exported to the hydraulic model.

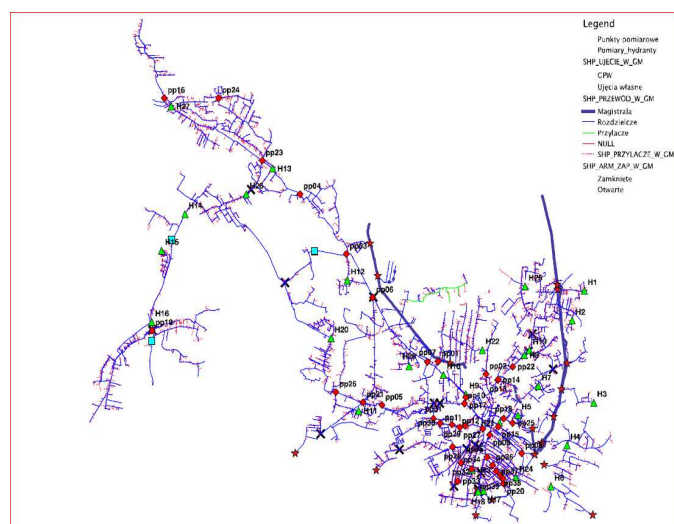


Figure 6. Graph of the water network modelled with the measurement points marked.

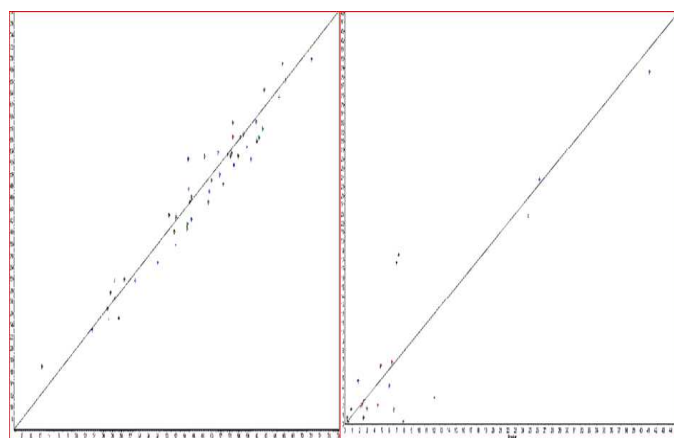


Figure 7. Calibration results for water pressures (left) and water flows as differences between measurements and calculations in monitoring points.

The calibration of the water net model was realized using the MOSKAN system and an algorithm of multi objects optimization with two criteria of quality defined for the deviations between the calculated and measured values of pressure and of flow. The results obtained are very satisfied for the correlation coefficient calculated for pressures equals to 97% and this one calculated for the flows equals to 90% (Fig. 7). In Fig. 7 the screen of MOSKAN assigned for water networks with the calibration results is shown; with different colours the flows and pressures with the values belonging to different value ranges are marked.

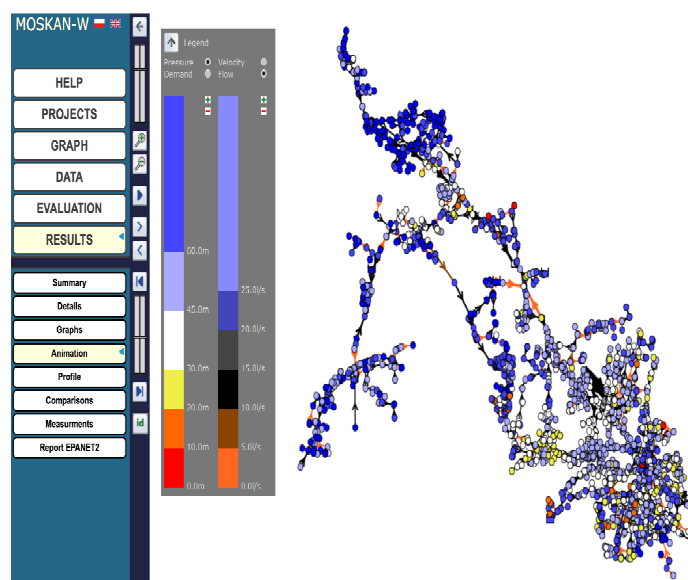


Figure 8. Results of hydraulic model calibration on the MOSKAN screen.

ICT for wastewater networks

Software MOSKAN dedicated for communal wastewater nets has been implemented in the Polish waterworks in Poznań on a selected reference catchment (Fig. 9).

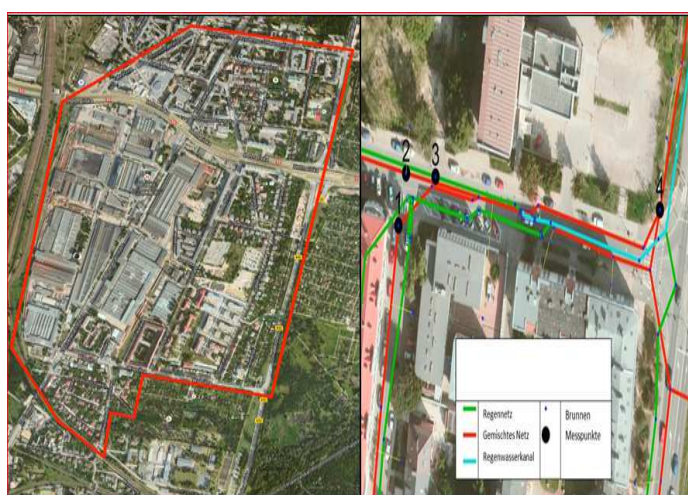


Figure 9. Catchment investigated (left) and SCADA point on the network.

Modelling of wastewater nets is more complicated than in case of water nets when only the hydraulic model for the network has to be formulated. By the wastewater nets three separated models for the network, the catchment and for the rainfalls are to make and the data generated by the catchment and rainfall models are then used as inputs for the network model. Also the network model for sewage systems is more complex than the model for water nets for it consists of differential equations which are more difficult to solve than the algebraic ones. The wastewater net given off for the modelling consists of 275 nodes and 285 canals. On this network a monitoring system is installed consisted of 4 measurement points assigned to measure the heights of canal fillings with the sewage and of 1 measurement point to measure the rainfalls (Fig. 9). Unfortunately 2 of 4 monitoring points for canal filling measurements were out of order during the time of the network modelling and the measurement data from only 2 points P1 and P2 could be used to calibrate the network model.

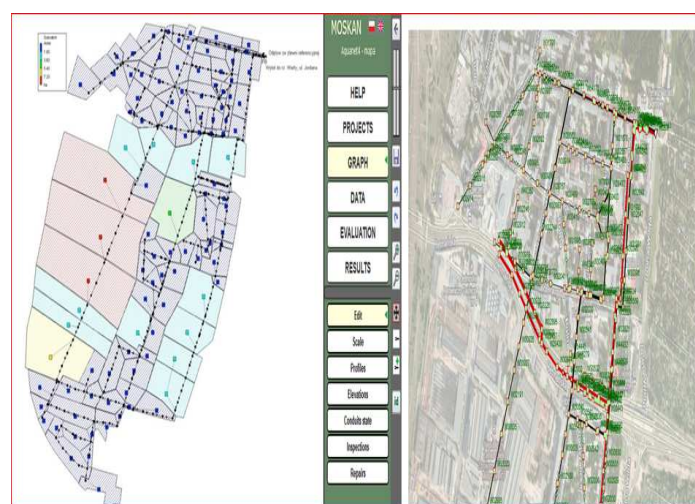


Figure 10. Catchment model (left) and network graph on the MOSKAN screen.

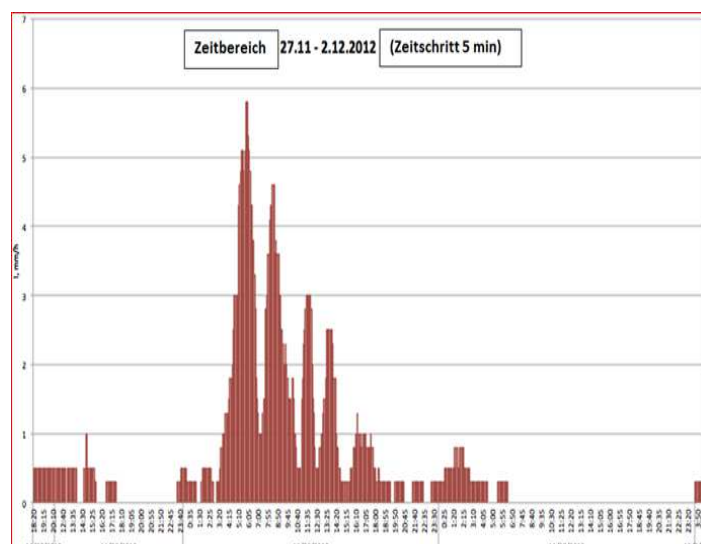


Figure 11. Rainfall model for the sewage network modelling.

While modelling the catchment it has been divided manually in 110 singular catchments for which the individual surface and slope values were calculated automatically using the tools of a GIS system. The catchment divided into singular catchments as well as its depiction on the screen of MOSKAN are designed in Fig. 10.

The data won from the monitoring devices are shown in Figures 11 and 12 and they concern the rainfall measurements and the canal filling heights measurements in the measurement points P1 and P2.

The calibration of the wastewater net model has been done by means of a multi object optimization algorithm and the model parameters that were optimized are roughness and dimension values of the canals. By the calibration of the whole sewage system consisted of the network, catchment and rainfall models also the catchment model was calibrated but it has been done by hand and the catchment parameters optimized are the soil porosity values changed individually for each singular catchment.

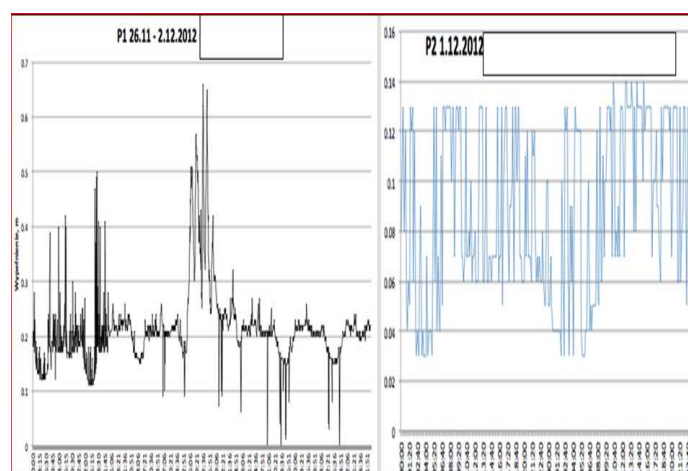


Figure 12. Measurements data from monitoring points P1 and P2.

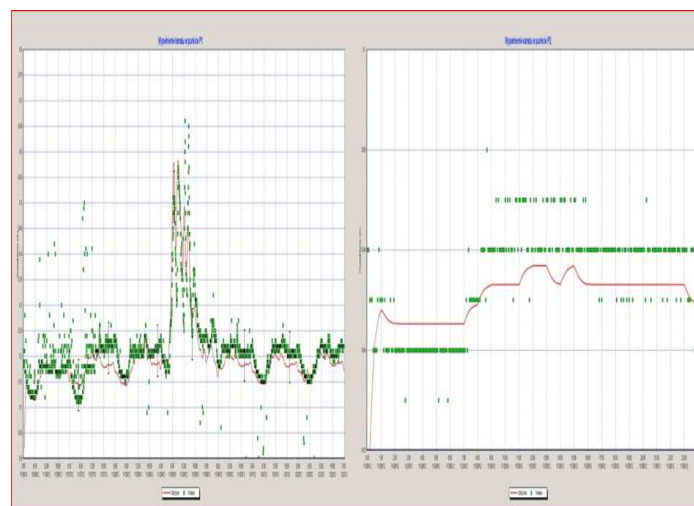


Figure 13. Calibration results for monitoring point P1 (left) and P2.

In Fig. 13 the calibration results are shown while the measuring data with red colour and the calculation results with

green one are marked. In general are the results satisfied as for the both monitoring points P1 and P2 the measurement and calculation data show a quite good accordance. The imitation of the measurements by the calculation results are better and more quantitative for point P1 than for point P2 for which they are of more qualitative kind; the reason for it is that also the measurements coming from this second monitoring point were of a rather poor quality (Fig. 12).

IV. CONCLUSIONS

The article describes a concept of integrated ICT system for supporting municipal waterworks management. The concept is based on the idea that has been developed at the Systems Research Institute (IBS PAN) in Warsaw in cooperation with Intergraph Polska responsible for including into the ICT system a GIS program and its integration with the monitoring and modelling and optimization programs.

Currently tested and also still developed modules support areas of water supplying and wastewater transporting and treatment systems. Water net and wastewater net ICT systems as well as the sewage treatment plant ICT system are enriched by numerous mathematical models and multi objects optimization and approximation algorithms that enable to support with computer technique all management tasks occurring in the waterworks. These tasks concern technical operation of the waterworks that could be called as waterworks *hard management* as well as organizational and administrative actions that could be called as waterworks *soft management*. These both kinds of management tasks are commonly realized in the waterworks separately with different programs what often leads to an information mess instead to cause the improvement of the enterprise management.

ACKNOWLEDGMENTS

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Analysing engagement towards the 2014 Earth Hour Campaign in Twitter

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Abstract—Earth Hour (EH) is a large-scale campaign launched by the World Wide Fund For Nature (WWF) every year to raise awareness about environmental issues. Although the EH campaign is active on social media, there is currently no systematic way of assessing its impact on public engagement and the topics they post about. In this paper we study engagement towards the 2014 EH campaign on Twitter. By analysing more than 35K tweets around the campaign we observed that longer posts, easier to read and with positive sentiment generated higher attention levels. Conversations were driven by the main themes of the campaign (super hero, the panda, etc.), but engagement towards these themes did not always translate in engagement towards environmental issues. Users decreased their engagement towards the topics of the campaign after it finished, but these topics still remained in their conversations one month later.

Keywords—Earth Hour, Social Media, Engagement Analysis

I. INTRODUCTION

Social media is now commonly used to help communicate messages to the general public. Many organisations have staff dedicated to this task and to improve the connection of the key messages with the wider public through social media. The World Wide Fund For Nature (WWF), as an organisation, disseminates messages to the public, on climate change, energy consumption, impact of fossil fuel extraction, conservation of endangered species, and other relevant topics that aim to help stopping the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.¹

Every year since 2007, WWF organises the Earth Hour (EH)² campaign, a campaign that challenges the citizens to switch off all lights for one hour. This event has grown from a one-city initiative to a mass global event involving more than 162 countries and 7,000 cities and towns. Its goal is not mainly to reduce carbon emissions, but to increase awareness about environmental issues.

To engage users in this event, WWF also uses social media channels, and specifically Twitter. With over 288 million monthly active users and 500 million messages per day,³

Twitter has become a rich resource for organisations to communicate their messages and to engage with the public. The work of this paper aims to understand the type and level of engagement generated by the EH campaign via Twitter. Signs of engagement include tweeting, retweeting, and replying to tweets about EH.

Engagement dynamics, i.e., understanding how and why users engage with certain pieces of social media content and not others have been recently studied in the literature [2][6][7][4][8][9][12]. However, little research has been performed on systematically assessing the effect that social media campaigns have on public engagement. In the case of EH, several works in the literature have studied the characteristics of the campaign by analysing the messages from the official Twitter accounts [1], its symbolism [5] and the effect of the campaign on reduction of electrical usage [13]. But, to the best of our knowledge, no studies have attempted to assess the impact of the campaign on public engagement.

In this work our focus is to assess how the messages and themes around the EH campaign influence the public. For this purpose, we study how users respond to and spread the word, and how they engage with the core themes of the campaign, during and after the campaign. In performing this study we make the following contributions:

- We discover some of the key characteristics of the Twitter messages that gathered high attention levels during the EH14 campaign.
- We identify the key themes that emerged during the EH14 campaign and analyse the user adaptability of those themes on Twitter.
- We show that the durability of the impact of EH topics on Twitter content is short-lived for the majority of users.

The rest of the paper is structured as follows: Section II provides a summary of the related work. Section III explains the data collection process and the dataset gathered to conduct our analyses. Section IV and V and VI explain the performed engagement analysis. Sections VII and VIII discuss and conclude the paper.

¹ http://wwf.panda.org/wwf_quick_facts.cfm

² <http://www.earthhour.org/about-us>

³ <https://about.twitter.com/company>

II. STATE OF THE ART

Recent years have seen a large body of research on measuring and predicting engagement across social media platforms. Engagement has been measured in different forms (e.g., retweets, replies to comments, popularity of posts and answers) in search for a better understanding of engagement dynamics and the features that influence engagement. For retweets, which is the main indicator of engagement used in this paper, it was found that content features were more influential than social features for determining whether a tweet will be retweeted or not [2][6][7][12]. For example, the presence of URLs and hashtags in the tweets were often found to be good indicators of retweetability [8][12]. Some social features, such as number of followers, followees and account age were also found to have some impact, although less than content features [12].

The role of topics in attention generation has also been investigated. It has been found that people are less likely to retweet on topics that they themselves tweet about [7], and that tweets on topics of general interest are more likely to be retweeted [8].

While these works have focused on understanding the different factors that influence engagement dynamics in different social networking platforms, little research has focused on understanding engagement towards the campaigns launched by social movement organisations, and specifically those around climate change and sustainability issues.

In [1] Campbell provides a comparative study of three climate change campaigns' Twitter accounts. This study observes that EH builds anticipation and momentum for the annual culmination of the campaign and engage followers by sharing user-generated content such as photos. Kazakoza [5] also studies the EH campaign construction and its symbolism. In this study she highlights the different modes of communication used within the campaign including – persuasion, rhetoric, images, advertising, news stories and other modes of symbolic action. While these studies analyse the characteristics of the EH campaign and the mechanisms used to engage with the public, these works do not assess the effect of those mechanisms and their impact on public engagement.

In the household context, the following works studied engagement towards the EH campaign in terms of reduction levels in energy consumption [11][13]. While electricity reduction is a countable metric, it only helps assessing engagement towards the campaign in a short period of time. It is also difficult to assess whether the actual reduction in energy is produced as a consequence of the campaign or because of other external factors.

This study aims to complement the previous works by assessing the impact of the EH14 campaign in public engagement. With this purpose, we investigate the different factors that trigger or influence engagement actions towards the messages and topics of the campaign in Twitter and we assess the persistence of this engagement up to a month after the event.

III. SOCIAL MEDIA DATA COLLECTION

This section presents a brief overview of the data that has been collected around EH14 in Twitter and the architectural solution developed to collect this data. The collection process consists of two steps:

- Step 1: collect tweets on EH. This was done using the official Twitter data collection services (i.e., Twitter Streaming API). This data will be analysed to study direct online engagement with EH campaign.
- Step 2: To study the level and longevity of the infiltration of EH topics into users' messages on Twitter, we need to analyse their messages beyond EH. Hence in step 2 we collect all previous tweets posted by each user found in Step 1 (up to a the max of 3,200 tweets set by Twitter). Analysing this data will help us to better understand the evolution of topics for the users who were engaged with EH.

The architectural diagram of our data collection solution is shown in Figure 1. As we can see the collector extracts data for four main units of information and stores them in a database. These units include: posts, replies/retweets, tags and users.

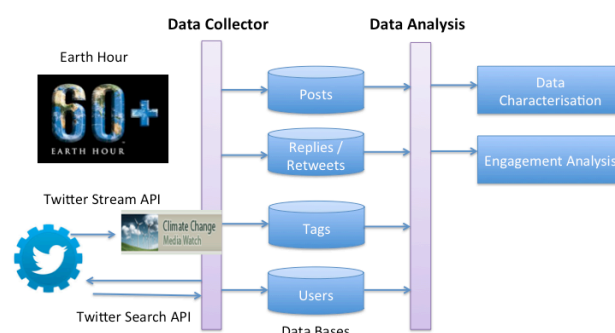


Figure 1: System Architecture

- Posts: information regarding the posts, including its own identifier, its author, its text, and the date it was created.
- Replies/Retweets: information about the messages that have been retweeted or replied. A message with a high number of replies and retweets indicates that the message is popular and is therefore engaging users in the conversation. These engagement indicators, in particular retweets, will be used later for the analysis presented in section IV.
- Tags: information about the set of hashtags mentioned in the tweets. Hashtags provide an indication of the topics that have been posted around the EH campaign.
- Users: information of those users who participated in the 2014 EH campaign in Twitter, including their geographical location, their profile description, the time since they joined the platform, etc.

The collected dataset contains more than 14 million posts produced by 6,195 users. Note that these posts contain data

around the 2014 EH campaign, as well as other topics of interests posted by the users over time. Within these posts we have 35,354 posts about the 2014 EH campaign which contain the keywords “earth hour” or “earthhour” or the hashtag “#earthhour”. Note that, for the analysis performed in sections IV and V we make use of the subset of 35K posts around EH, while we use the complete dataset for the analysis performed in section VI.

IV. ENGAGEMENT ANALYSIS

Once the data has been collected our goal is, first to characterise engagement towards the EH campaign in Twitter, and second, to study which factors influence engagement.

A. Indicators of Engagement

In the Twitter platform, retweeting, replying and favouring are actions that require an explicit interaction from a user towards another user. These actions have been repeatedly considered in the literature on social media [7][9][12] as engagement indicators. Note that, when retweeting, as opposed to when favouring or replying, users are spreading the word to their followers, which constitutes a stronger involvement and engagement with the issues posted around the EH campaign. In total, the posts generated around the EH campaign received 261,487 retweets. For an overview, the following table shows the top 5 retweeted posts.

Table 1: Top 5 retweeted posts around Earth Hour

Post	Retweets
RT @ArianaGrande: Joining the movement by going dark for #EarthHour on March 29 from 8:30-9:30 pm /hR0mUi5JT4 @World_Wildlife yo...	4901
RT @earthhour: Join the world for #EarthHour at 8:30PM local time wherever you are in the world. Use #YourPower at /HxefGDqjDL	2721
RT @earthhour: #EarthHour 2014 shows our world is full of Superheroes for the Planet. Join the movement at /HxefGDqjDL http://t...	2316
RT @earthhour: #EarthHour 2014, inspiring a new generation of Superheroes for the Planet. You can mobilise the Power of Youth at http://t.c...	1874
RT @Ennui_Raver: Gucci mane turn off youre blackberry torch. It earth hour. You piece of shit. Yuo fuckin piece of shit turn off your black...	1831

B. Characterising Users and Content

In this section we propose different features to characterise the EH14 messages (how they are written, when they are published, etc.) as well as the users who posted or engaged with those messages. Our goal, by using these features, is to identify the main characteristics of those users and posts generating higher levels of attention during the EH campaign in Twitter.

A large-body of literature already exists that have studied engagement dynamics in different platforms, proposing for this

purpose the use of different features [2][6][7][4][8][9][12]. In this work we have selected those features that are common across social media platforms [9]. These features are listed in Table 2.

Table 2: User and Content Features

User Features	
<i>In-degree</i>	Number of incoming connections to the user
<i>Out-degree</i>	Number of outgoing connections from the user
<i>Post Count</i>	Number of posts that the user has made over her account life in Twitter
<i>User Age</i>	Length of time that the user has been a member of Twitter
<i>Post Rate</i>	Number of posts made by the user per day
Content Features	
<i>Post length</i>	Number of terms in the post
<i>Complexity</i>	Concentration of language and its dispersion across different terms. This feature aims to study whether posts receiving high attention levels contain many terms which are not repeated often or rather repeat terms from a limited vocabulary. Specific details of this metric can be found in [9].
<i>Readability</i>	This feature gauges how hard the post is to parse by humans. To measure readability we use the Gunning Fox Index ⁴
<i>Referral Count</i>	Number of hyperlinks (URLs) present in the posts
<i>Mentions</i>	Number of mentions to other users within the posts
<i>Informativeness</i>	The novelty of the post's terms with respect to the other posts. We derive this measure using the Term Frequency-Inverse Document Frequency (TF-IDF) measure. Specific details of this metric can be found in [9].
<i>Polarity</i>	Average polarity (sentiment) of the post. We are computing sentiment by using SentiStrength, ⁵ a state of the art method for analysing sentiment in social media data. For specific details of how sentiment is computed for each particular tweet, the author is referred to the list of scientific publications behind this library. ⁶
<i>Time of the day</i>	Time when the tweet was posted (e.g., 20:00)

C. Mining Engagement Dynamics

To identify the key characteristics of the posts and users that attracted higher attention levels during the EH14 campaign we perform two different analyses:

- First, we identify the characteristics of those tweets that are followed by an engagement action (retweet). We call these tweets the seed posts. As we can see in Table 3, 22,623 posts (64% of the posts in our dataset) received at least one retweet.
- In a second step we identify the characteristics of those posts that were followed by a higher number of engagement actions (i.e., received a higher number of retweets)

⁴ http://en.wikipedia.org/wiki/Gunning_fog_index

⁵ <http://sentistrength.wlv.ac.uk/>

⁶ <http://sentistrength.wlv.ac.uk/#About>

Table 3: Seeds vs. non seeds posts in Earth Hour Dataset

Dataset	Posts	Seed	Non seed
Earth Hour	35,354	22,623 (64%)	12,731 (36%)

Characterising Tweets Receiving an Engagement Action

To perform the first task, we train three different Machine Learning (ML) classifiers (Naïve Bayes, J48 and Support Vector Machines) using historical data, and select the one that provides the most accurate classification of seed posts from non-seed posts. This classifier automatically assesses the probability of a tweet to generate attention and engagement, depending on the features of the tweet. To generate the different classifiers we use a balanced dataset of randomly selected 12K seeds vs. non-seed posts and use 10-fold cross validation to test their performance.

Once the optimal classifier is identified (in this case the J48 decision tree), we remove one feature at a time from the classifier, and measure the drop in performance. Those features that generate a higher performance drop are the most discriminative ones, i.e., they are the ones that better distinguish the seed posts (those generating engagement) from the non-seed posts (those that are less likely to be retweeted).

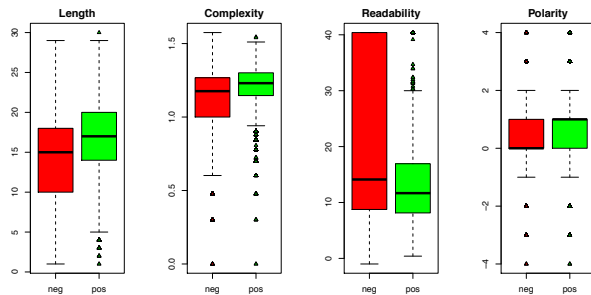
**Figure 2: Features with higher influence on engagement levels**

Figure 2 shows the result of this analysis. More particularly, the top 4 discriminative features that help distinguishing seed from non-seed posts are: readability, post length, complexity and polarity. Posts generating attention (i.e., being retweeted) are slightly longer, easier to read, have positive sentiment and tend to repeat terms existing in other posts. Note that readability is measured using the Gunning Fox Index. This index estimates the years of formal education needed to understand the text on a first reading (i.e., the lower the index level, the easier is for a text to be read).

It is important to highlight that the key discriminative features to identify retweets do not include any social features, meaning that, in terms of generating engagement towards the EH campaign, the content of the tweet is more relevant than the reputation of the user.

Characterising Tweets Receiving High Engagement

For our second analysis the goal is to determine which are the characteristics of those seed posts generating higher attention levels (i.e., receiving a higher number of retweets). To obtain this information, we induce a linear regression model, where the different attributes or features listed above are used

to approximate the number of engagement interactions (i.e., the number of retweets) that a tweet is receiving.

Table 4 presents the results of this analysis. By inspecting the coefficients of the regression model we can observe how the change in each feature is associated with the likelihood of engagement (i.e., how the change in each feature would impact the likelihood of the post being retweeted).

The more significant features are readability, informativeness, polarity, mentions, and out-degree. This means that posts followed by a higher number of engagement actions are easy to read, repeat keywords and themes present in other posts have positive sentiment and mention other users.

Table 4: Regression Coefficients. Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1**

Feature	Regression Coefficient	Significance
length	8.93E-01	
complexity	1.10E+02	**
readability	-1.49E+00	***
referral count	4.81E+00	*
informativeness	-2.25E+00	***
polarity	1.17E+01	***
mentions	2.72E+01	***
timeDay	-8.71E-01	
indegree	1.69E-05	
outdegree	-1.20E-03	**
postcount	1.59E-04	
age	8.48E-04	
postrate	4.57E-01	

V. TOPIC ANALYSIS

The following section aims to investigate the key themes that emerged during the EH14 campaign. To extract these themes we have followed two main steps:

- The first step aims to analyse the hashtags contained within the tweets. Hashtags are keywords preceded by the # symbol that users include in the tweets to express their main themes.
- The second step uses automated semantic annotators to process the text of the tweet and to identify the key entities (places / products / companies, etc.) that appear in the tweets under analysis.

A. Hashtag Topic Analysis

The tag cloud displayed in Figure 4 shows the main hashtags appearing in the EH dataset. The size of the hashtag is an indication of its frequency within the dataset. The colours are for better visualisation but do not convey any meaning. Note that we have removed the main hashtag (#earthhour) for a better visualisation, since its frequency (13,898 occurrences) is significantly higher than the one of the other hashtags. The

second most frequent tag is iniaksiku with 2,080 occurrences. The main hashtags of interest during the campaign are listed in the following table:

Table 5: Top EH hashtags

Hashtag	Meaning
iniaksiku	Term used during the campaign in Indonesia. It means 'ini aksiku, mana aksimu' (this is my action, what is yours). It is the Indonesian version of IWIYW (I will if you will)
Earthhourza	Domain name of South Africa. Tweets with these Hashtag aimed to identify content regarding the EH South African campaign
earthhour2014	is the identifier of the year 2014 EH camping
yourpower	Represents the campaign slogan "use your power to make change a reality"
passthepanda ⁸	Campaign action in which several teddy panda bears were given to people so that they keep passing them to raise awareness.
Turnofftoturnon, durexsexplorers, getclosergofurther ⁹	These hashtags are part of the Durex promotion of the EH campaign. Their goal is to reconnect couples when the lights are switched off
spiderman ¹⁰	In the 2014 year's campaign, Spiderman was selected as ambassador
bebrilliant	This hashtag represents a message of the original campaign "Be a part of Earth Hour - the world's biggest celebration for our brilliant planet ¹¹ !"
welshwish ¹²	Campaign that the Wales rugby stars launched to promote EH
momentofdarknes	Moment when the lights are switched off
Earthhouruae	Campaign of the United Arab Emirates
tahiti ¹³	Campaign conducted in the French Polynesia, and more particularly, the concert taking place in Tahiti

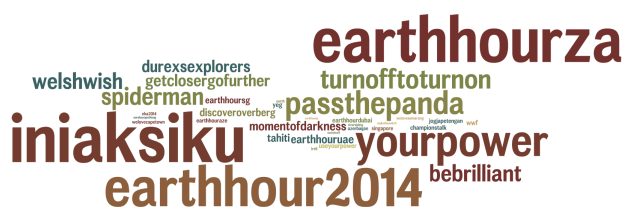


Figure 3: Top hastags within the EH dataset

This analysis reveals that the top themes found in the tweets are the ones promoted by the EH campaign.

B. Semantic Topic Analysis

Additionally to the analysis of hashtags (which are keywords explicitly expressed by the users) we have processed

the posts with a semantic annotator, in this case TexRazor,¹⁴ with the purpose of identifying the key entities and concepts within the EH dataset. TextRazor offers a text analysis infrastructure. It combines state-of-the-art natural language processing techniques with semantic knowledge bases to extract the key entities and concepts from documents.

As we can see in Table 6 the top 15 identified entities include: Planet, World_Wide_Fund_for_Nature, Superhero, Durex, Cape_Town, Twitter, Singapore, Indonesia, climate_change, Wales, Andrew_Garfield, Reef, and Energy. The entity names are similar to the hashtags identified by our previous analysis or refer to similar topics (e.g., Wales refers to the campaign that the Wales rugby stars lunched to promote EH, Andrew Garfield is the actor of Spiderman, the super hero selected for 2014 EH campaign, etc.). The main addition provided by the semantic analysis is that we are now able to identify concrete concepts: locations, organisations, persons, etc., appearing within our dataset.

Table 6: Top Entities

Entity	Frequency
http://en.wikipedia.org/wiki/Earth_Hour	12566
http://en.wikipedia.org/wiki/Earth	1803
http://en.wikipedia.org/wiki/Planet	915
http://en.wikipedia.org/wiki/Hour	798
http://en.wikipedia.org/wiki/World_Wide_Fund_for_Nature	672
http://en.wikipedia.org/wiki/Superhero	424
http://en.wikipedia.org/wiki/Durex	376
http://en.wikipedia.org/wiki/Cape_Town	367
http://en.wikipedia.org/wiki/Twitter	334
http://en.wikipedia.org/wiki/Singapore	328
http://en.wikipedia.org/wiki/Indonesia	227
http://en.wikipedia.org/wiki/Climate_change	226
http://en.wikipedia.org/wiki/Wales	220
http://en.wikipedia.org/wiki/Andrew_Garfield	220
http://en.wikipedia.org/wiki/Reef	203
http://en.wikipedia.org/wiki/Energy	201
http://en.wikipedia.org/wiki/Candle	201

For example, among the top organisations driving engagement towards the campaign we can highlight some of the main organisers and contributors, such as the World Wide Fund for Nature, Durex or Twitter; media and entertainment organisations, such as Instagram, THX, YouTube, WWE, Facebook and Verizon_Communications; and international organisations dedicated to the research and development of sustainability, such as ICLEI, York_University, National_Institutes_of_Health, etc.

Key persons/celebrities that help to raise awareness about the campaign in social media include: Andrew_Garfield, Emma_Stone, Jamie_Fox, Gucci_Mane, Marc_Webb and Sophie_Ellis-Bextor. Andrew Garfield, Emma Stone, Jamie Foxx and Marc Weeb are actors of the Spiderman film (the EH 2014 super hero). Gucci mane is an American rapper, target of the popular tweet "Gucci mane turn off your blackberry torch. It earth hour. You piece of shit. Yuo fuckin piece of shit turn off your blackberry". Sophie Ellies Bextor was one of the celebrities performing for the EH campaign in London. Among the politicians we can highlight Crhistiana Figueres, Executive

⁷ <http://www.earthhour.org/>

⁸ <http://earthhour.wwf.org.uk/get-involved/pass-the-panda>

⁹ <http://www.thedrum.com/news/2014/03/18/durex-promotes-earth-hour-turnofftoturnon-campaign-spanning-56-markets-worldwide>

¹⁰ <http://www.earthhour.org/superhero3>

¹¹ <https://www.facebook.com/EarthHourUK>

¹² http://wales.wwf.org.uk/wwf_articles.cfm?unewsid=7039

¹³ <http://www.earthhour.org/french-polynesia>

¹⁴ <https://www.textrazor.com/>

Secretary of the UN Framework Convention on Climate Change and David Miller, Canadian former politician and president of WWF-Canada.

The previous analyses reflect the topics/entities that were more popular among users during the EH campaign. To investigate whether the topics and elements used to promote the campaign (the Super hero, Durex, the participation of the Wales rugby stars) stimulate awareness towards topics such as climate change, energy, sustainability, etc., we have performed a correlation analysis between the top 10 most frequent entities within our dataset. Correlation is measured considering the distribution of entities per user.

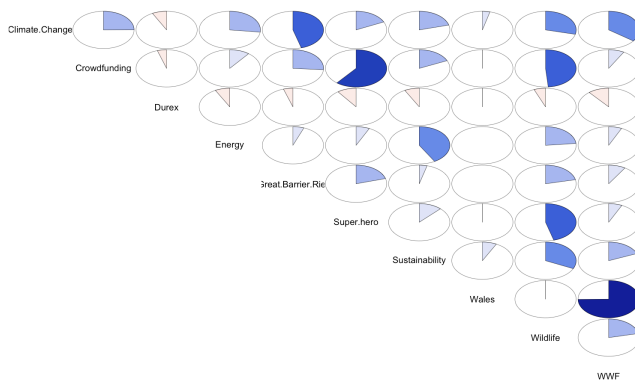


Figure 4: Frequencies of co-appearances among the most frequent entities

The results of the performed analysis are displayed in Figure 4. Red means, negative correlation, blue positive correlation. Colour intensity indicates intensity of the correlation. As we can see in this image, there is a low or negative correlation between Durex and any other entity, meaning that users tweeting about Durex during the EH campaign did not show any particular interest about climate change, sustainability, or any other entity.

Users talking about climate change also mentioned themes around the Great Barrier Reef, wildlife, or WWF. Energy is strongly correlated with sustainability, and sustainability is correlated with wildlife. However, these entities have low-medium correlations with the main elements of the campaign, such as Crowd funding, Durex, the Super Hero or the Wales rugby stars. This indicates that, while the main activities and themes of the campaign did drive most of the social media conversations, the fact that the users engaged in these themes did not necessarily mean that they also engaged with climate change and sustainability issues.

VI. TOPIC PERSISTENCE

In this section our main purpose is investigating the persistence of engagement towards the EH topics among the users who participated in the campaign. For this purpose we consider not only the 35K tweets about the campaign (which were the ones used for our previous analyses) but also the additional tweets posted by the 6K users who generated those tweets (see Section III for more details about the data

collection process). We restricted this analysis to one month before and one month after the campaign.

We extracted the key topics of discussion during these two months by applying the Latent Dirichlet Allocation (LDA) algorithm [1] with a number of 50 topics. LDA looks at the distribution of words in different documents (in our case tweets) and generates different topics (groups of words). By performing LDA we derive the latent topics discussed within the two-month period surrounding EH. Examples of these topics are displayed in Table 7:

Table 7: Examples of Topics

Topic	Percentage
photo facebook posted	2%
news south singapore	2%
day good morning	3%
energy climate change	3%
weather rain high	2%
missing malaysia flight	2%
people work women	3%
earth hour earthhour	2%

In order to better understand how users' discussions are centred around EH, we compare topic distributions at different points in time against the EH reference distribution.

We generate the EH reference distribution by considering all the tweets about EH during the day of the campaign. We perform the same process to obtain a topic distribution for each day before and after the campaign and compare each topic distribution against the EH reference distribution by using the Jensen-Shannon divergence (JSD) between the topic distributions.

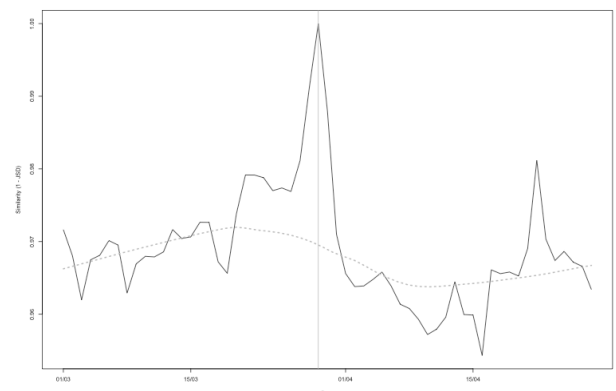


Figure 5: Topic Similarity of topic distributions of different points in time against the EH reference distribution

As it can be observed in Figure 5, topic distributions get similar to the EH topic distribution as we get closer to the day of the campaign. Then, topic distributions start fading, as the users go back to their usual conversations. Nevertheless, it appears that topics of discussion maintain some similarity to the topics of EH, meaning that, after the campaign is finished,

users maintain some level of engagement towards the topics of the campaign.

VII. DISCUSSIONS

One of the most fascinating dimensions of social media is the way in which it allows individuals and organisations to engage with large audiences, helping them spreading relevant ideas and messages. In this paper we have focused on assessing how the 2014 EH Twitter campaign influenced public engagement.

Our observations indicate that, in terms of generating engagement, the content of the tweet is more relevant than the reputation of the Twitter user who posted it. This was also observed by previous studies focused on analysing engagement dynamics in different social media platforms [2][6][7][12]. Posts generating higher attention levels are slightly longer, easier to read and have positive sentiment. These “recipes” for writing posts are now being used as recommendations for future EH campaigns. Posts will be shaped using longer text, expressing simple and positive messages, in order to increase engagement.

Our selection of user and content features was inspired by the literature [9], and consisted of features that were found relevant, in one aspect or another one, to identify engagement. However, we acknowledge the fact that there could be other features that might better characterise engagement in the context of this particular campaign.

By analysing the topics of these tweets we observed that, while the main activities and themes of the campaign (the 2014 EH super hero, the panda, etc.) did drive most of the social media conversations, the fact that the users engaged in the campaign, did not necessary mean that they also engaged with climate change and sustainability issues. This is an important lesson learned, since the goal of EH is to raise awareness about climate change. Future editions of the campaign should therefore work on emphasising more the relevant messages that WWF as organisation aims to transmit to the public.

By studying the temporal evolution of these topics we also observed that, while users decrease their engagement towards the topics of the campaign after it finished, these topics still remained, with less intensity, in their conversations one month later. This positive result indicates that the campaign not only triggered short-term engagement, but that some of the key messages did persist in the Twitter conversations during at least a month after the campaign. However, more extensive research needs to be done to assess the long-term effect of the campaign in terms of engagement. This action requires the collection and analysis of data for at least one year, to cover the period between events, which is part of our future work.

Further experiments are also needed to shed more light on the actions or strategies that get users to get engaged. Note that, for the purpose of this study we collected information from users who were participating in the 2014 EH campaign. However, we don't know which of those users were already aware about the campaign and were already engaged with climate change and sustainability issues and which ones got engaged because of the strategies and interventions conducted

during the campaign. Further research is therefore needed to assess the effect of these interventions by using a control group (i.e., users who were never involved with EH).

It is also relevant to mention that, while for this study we considered all tweets around EH, some of those tweets were not produced by citizens, but by Twitter accounts belonging to WWF and other relevant organisations. Our aim for analysing the next EH campaign is to profile and filter these social media accounts and to differentiate citizen engagement vs. engagement actions produced by organisations associated to the campaign.

In summary, while there is still extensive room for future work, or experiments and results highlight some of the effects of the 2014 EH campaign in public engagement. We hope that the presented study will serve as a basis for future work within the community and enable further research into the systematic assessment of engagement produced by climate change campaigns and actions.

VIII. CONCLUSIONS

Although much research has been done on identifying the factors that influence engagement in social media, very little attention has been giving to measuring the impact that climate change campaigns and actions have on public engagement.

This paper aimed to study the impact of the 2014 EH Twitter campaign. For this purpose we collected 35K tweets around the EH campaign in Twitter. By analysing these tweets we observed that, in terms of generating engagement, the content of the tweet is more relevant than the reputation of the user. Posts generating higher attention levels are slightly longer, easier to read, have positive sentiment, mention other users and tend to repeat terms existing in other posts.

By analysing the topics of these tweets we observed that, while the main activities and themes of the campaign (super hero, the panda, etc.) did drive most of the social media conversations, the fact that the users engaged in the campaign, did not necessary mean that they also engaged with climate change and sustainability issues. Studying the temporal evolution of these topics we also observed that, while users decrease their engagement towards the topic of the campaign after it finished, these topics still remained in their conversations one month later.

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Energy Atlas Schleswig-Holstein

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Abstract—The energy atlas Schleswig-Holstein represents an instrument supporting the state authorities in performing their tasks in order to promote the energy transition towards renewable energy supply. The web application energy atlas makes governmental data about wind turbines and biogas plants available combined with comprehensive evaluation functions including digital maps presenting the energy plants in the context of other thematic layers like land use. The energy atlas is one of the first applications integrated in a special area of a new data center, observing new challenges and options.

Keywords—energy transition; energy maps, wind turbines, biogas plants, spatial information system; data warehouse; Cadenza

I. OVERVIEW

A. Motivation and Basics

To adequately support the energy transition towards renewable energy supply in Schleswig-Holstein an instrument was required in order to make information about renewable energy plants available to all relevant state authorities. This includes especially data which already are maintained in governmental information systems.

The energy atlas Schleswig-Holstein was planned to present among others the following data:

- Further potential of renewable energy development
- Rivalry between renewable energy and other land use (cf. [4], [5])
- Further demands on network expansion
- Development of different energy generating methods in Schleswig-Holstein

The following aspects had to be considered when designing the energy atlas:

- Using existing information held by the state authorities
- Building a flexibly extendable tool
- At first making data available only for the state authorities including all concerned departments (access for local authorities should also be possible later)

The energy atlas was planned as a first step to monitor the implementation of the energy transition in Schleswig-Holstein.

The screenshot displays the 'Recherche nach Anlagen' (Search for facilities) page of the Energy Atlas Schleswig-Holstein. The interface is divided into a left sidebar for filters and a main table for search results. The sidebar includes a 'WINDKRAFT' (Wind Power) section with filters for 'Rotordurchmesser [m] (von/bis)', 'Nabenhöhe [m] (von/bis)', 'Gesamthöhe [m] (von/bis)', and 'Leistung [kW] (von/bis)'. The main table lists search results with columns: 'Anlagenart', 'Anlagenbezeichnung', 'Rechtswert', 'Hochwert', 'Genehmigungsdatum', and 'Inbetrieb'. The table shows 107 results, with the first few rows listing wind turbines (WKA) and their associated data. The bottom of the interface shows a footer with 'Cadenza Web v6 3.1' and '© 2014 GeoBasis-DE / BKG (http://www.bkg.bund.de)'.

Fig. 1. Searching for wind turbines according to different criteria



Fig. 2. Visualization of search results on the digital map based on the software platform CadenzaWeb

The technical operation should be centralized at the state's IT service provider Dataport.

The Ministry of Energy, Agriculture, the Environment and Rural Areas Schleswig-Holstein (MELUR) is responsible for the general management of the energy atlas' realization. So the energy atlas forms also a pilot application in the sense of proving the process model according to the MELUR data warehouse strategy.

B. Development Steps

With the “Integrated Energy and Climate Protection Concept for Schleswig-Holstein“ the government of Schleswig-Holstein gave the impulse for building an energy atlas already in 2011, which lead to the design of the according information system in 2012.

After the change of government in 2012 the main focus on energy politics was even emphasized which included the expansion of the department's name to Ministry of *Energy, Agriculture, the Environment and Rural Areas*, who took the lead management in developing a prototype, supported by the State Chancellery. Accompanied by a project group the company DigSyLand was mandated with the development of a web application, first to be offered only in-house, but in future to be extended to a public information platform including local acquisition of further relevant data.

During summer 2012 the first prototypical application was released for all MELUR related authorities and afterwards was further developed according to the project group's demands in the following months.

With the new data center of Dataport, called RZ², beginning to operate in 2013 plans were initialized to realize the energy

atlas within the frame of a newly designed data center area called “MELUR service area” meeting the special needs of the Ministry within a special project called ZeBIS¹.

Conceptual design and composition of the MELUR service area began 2014, so that the energy atlas was one of the first applications to begin live operation in this area.

II. INFORMATION OFFERED BY ENERGY ATLAS

A. Evaluation of wind turbines and biogas plants

The search for wind energy and biogas plants according to different criteria offers one possible entry point for using the energy atlas. Criteria include administrative details like name of plants, operator, dates of permission and of initial operation, and address information but also plant specific data. Wind turbines can be queried by power and dimension related parameters, while biogas plants are described for instance by combustion heat performance and permitted raw materials.

The employed software platform CadenzaWeb (see Ch. III) offers the standard functionality of displaying all results in a tabular form while refining the search criteria (Fig. 1).

All results presented in the table could also be downloaded in an Excel file to be further edited and evaluated. So-called permalinks could be generated: web addresses (URL) pointing to the results which can be called later again and can be shared with others.

¹ ZeBIS: Zentraler Betrieb der Informationssysteme im Geschäftsbereich des MELUR (central operation of information systems in the MELUR's business area)

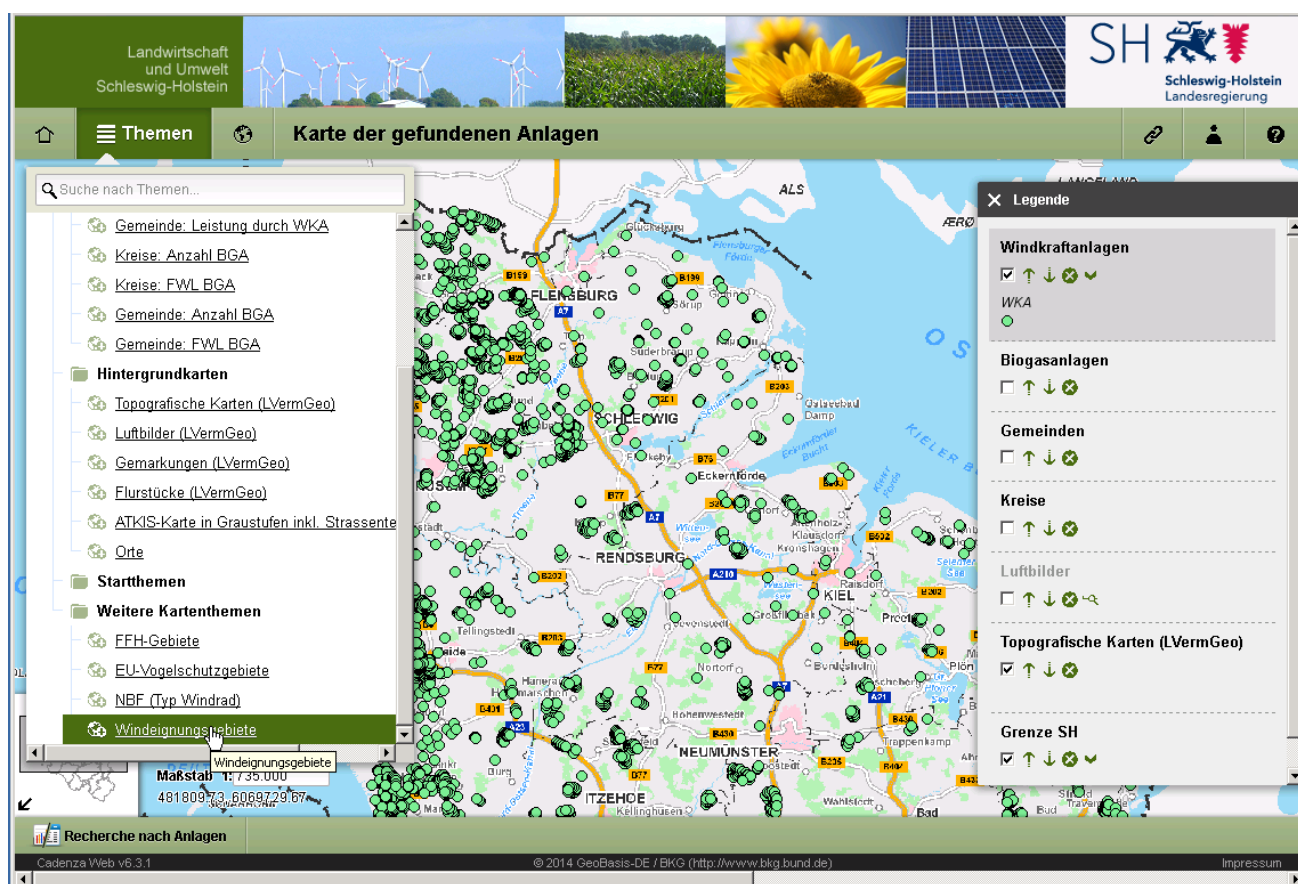


Fig. 3. Presentation of energy related thematic map layers added by query functions

The presentation of all resulting power plants on the digital map is another important feature. The search results can be combined with other thematic map layers and for instance with other relevant land use (Fig. 2).

Details about each presented power plant can be queried by mouse click on the map.

B. Thematic Map Layers

Different topical and administrative map layers are accessible in addition to the energy plant locations which can be combined as background layers with search results or can serve as an alternative map-based entry point to the atlas. These map layers include administrative boundaries like districts and parcels integrated via WMS (Web Map Service), provided by the geo information agency LVerGeo SH, as well as potential wind energy areas, Natura 2000 protection areas and certain agricultural zones (Fig. 3).

C. Evaluation Maps

The mentioned background layers are complemented by so-called evaluation maps which were generated by aggregation of plant related parameters according to the spatial units of municipalities and districts. These visualizations include for instance the number of wind energy plants per municipality

and use different colors to mark the various magnitudes (Fig. 4).

III. TECHNICAL BASICS

A. Conceptual Guidelines

The first step composing the energy atlas should base as far as possible on existing data and software systems run by the state authorities.

The specification postulated to use data about plants regulated by immission control legislation maintained within the information system LIS-A (LänderInformationssystem für Anlagen: state information system for facilities). The State Agency for Agriculture, Environment and Rural Areas of Schleswig-Holstein (LLUR-SH) manages the data performing the role of the responsible permit authority. Data relevant for the energy atlas concern onshore wind turbines (higher than 50 m) and biogas plants.

B. Evaluation Platform Disy Cadenza

It was decided to implement the energy atlas basing on the platform Disy CadenzaWeb. Disy Cadenza represents a comprehensive data evaluation and GIS software platform used by several federal states as well as by Schleswig-Holstein's agricultural and environmental authorities. Cadenza had been

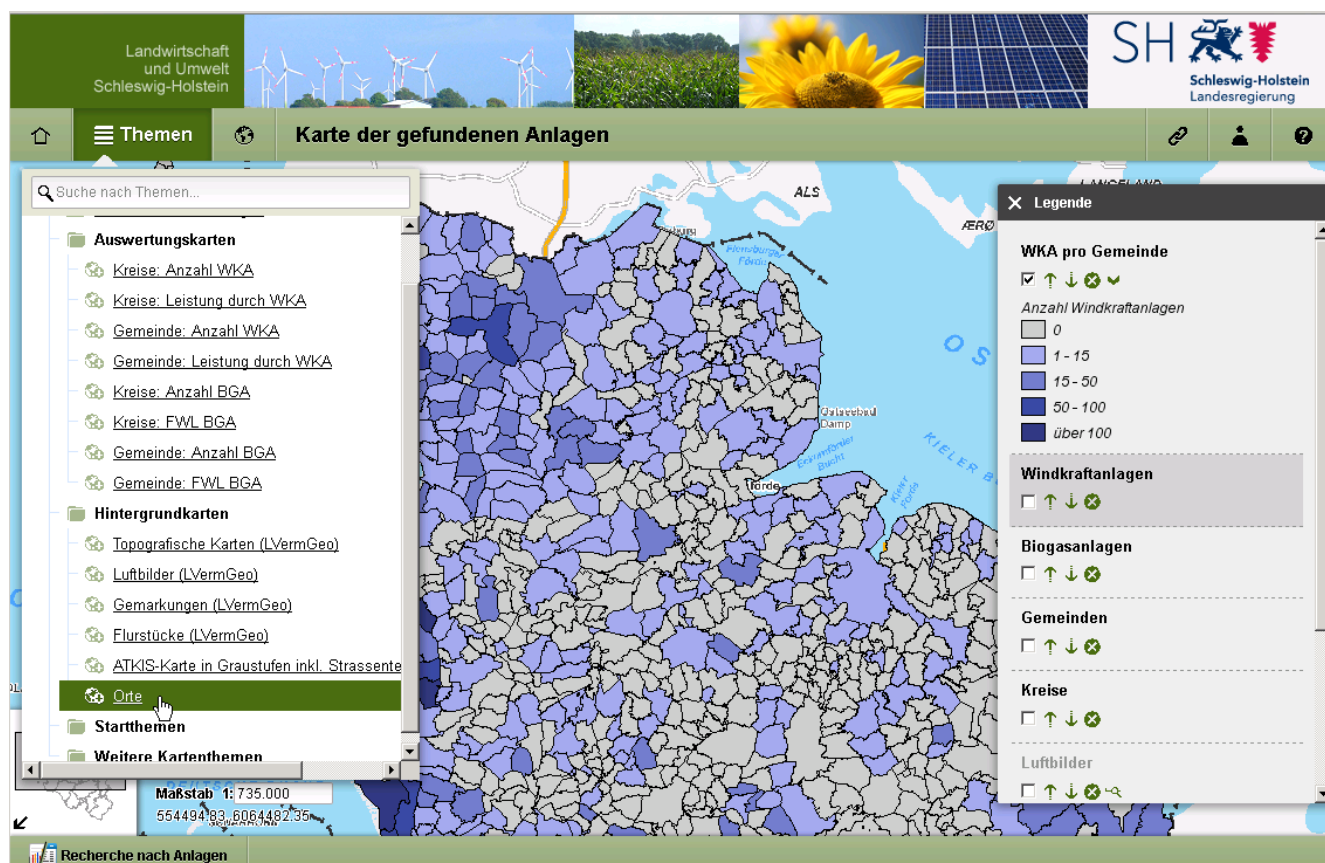


Fig. 4. Evaluation maps present power plant details aggregated on municipality or district level

proven to be well-suited for environmental data evaluations since many years in Schleswig-Holstein, so that the energy atlas development could rely on the acquired know-how as well as on the technical basis. Among other application fields Cadenza supports evaluation and reporting tasks according to the EU Water Framework Directive [3] as well as the management of nature conservation measures [2] and the implementation of the Environmental noise directive in Schleswig-Holstein [1].

Cadenza offers a platform which on the hand is available as a Java based desktop application called Cadenza Professional enabling the experts to perform combined evaluations of topical data and geo data with the comfort and range of functionalities of a typical desktop application. Within Schleswig-Holstein's state authorities the Java webstart technique is employed to minimize installation effort. On the other hand a second variant, called CadenzaWeb, can be used to build Cadenza based web applications. CadenzaWeb includes also comprehensive evaluation and presentation features but is limited in comparison to the desktop version, which makes it especially well-suited for non-expert users.

Both Cadenza editions can access the same data sources and the same management structures, called repository. The

common tool repository manager facilitates the administration tasks.

For the implementation of the energy atlas CadenzaWeb was chosen because all authorities can use the application without any installation via their standard web browser (s. Fig. 6).

C. Data Management

All data are managed by an Oracle RDBMS, the standard database management system used by the state administration.

Cadenza integrates direct access to topical data as well as to spatial data maintained in Oracle using the standard Oracle spatial formats. Additional access to geo data held in shape files and access to OGC services like WMS and WFS is also possible.

D. Data Compilation via ETL Processes

In close cooperation with the responsible experts ETL processes (ETL: extract, transform, load) were created in order to extract the relevant data from the LIS-A system and to transform them within a staging database into a form to be used by the energy atlas (s. Fig. 5).

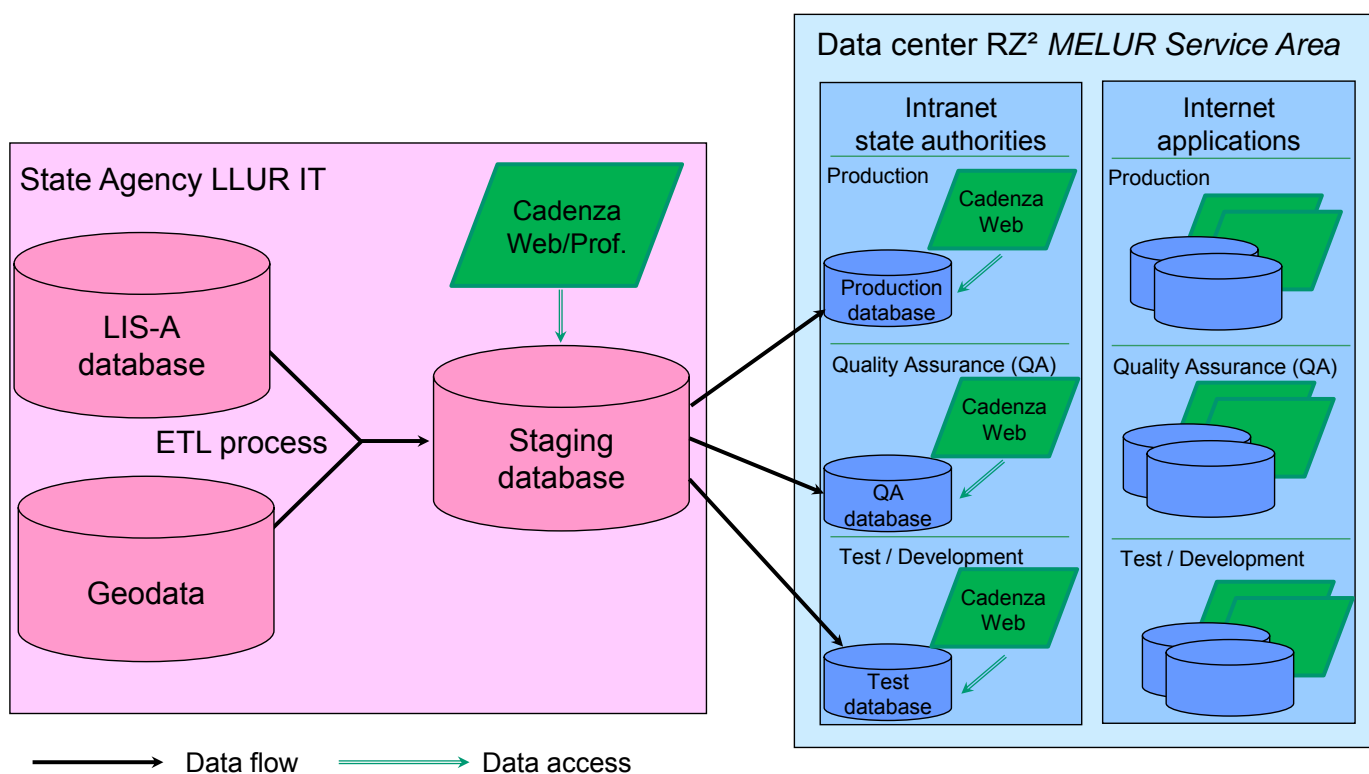


Fig. 5. Energy atlas related data flow into data center RZ² (MELUR service area) with different Oracle databases involved

The ETL processes incorporate also the conversion of coordinate data held in LIS-A into Oracle geometries as well as the spatial aggregation of plant specific parameters as a base for generating the atlas' evaluation maps (s. Ch. IIC, Fig. 4). Being executed each night the ETL processes ensure the availability of up to date information for research and presentation by means of the energy atlas.

A local test instance of the energy atlas based on CadenzaWeb in the state agency enables the experts of LLUR and MELUR to test the system and perform quality assurance tasks on the compiled data (s. Fig. 5, left part).

E. Availability for all Authorities in the Data Center RZ²

The design during the conceptual phase already proposed the operation of the energy atlas by Dataport, the state's central IT service provider. So availability could be ensured not only for the MELUR related authorities but for all state authorities. This includes especially access by the State Chancellery, a member of the energy atlas project group.

The energy atlas was one of the first applications to be realized within the framework of the project ZeBIS using the central Cadenza platform located in the MELUR service area within the newly build Dataport data center RZ² (s. Ch. IB).

One major challenge consisted in satisfying the ambitious technical and security related specifications of the data center as well as the demands of the ministry MELUR which has to

react flexibly on current requirements and has to consider heterogeneous data structures and data flows.

All involved organizations like the companies Disy and DigSyLand, Dataport and the state authorities LLUR and MELUR developed suitable access mechanisms and replication processes in close cooperation facilitating that all required data are nightly transferred into the data center RZ² enabling the presentation of current data by the energy atlas (s. Fig. 5).

Within the MELUR service area applications available in the Internet and applications accessible only for the state authorities are maintained in different zones, separated by security measures like firewalls. Each zone is divided in three environments (s. Fig. 5):

- Test and development environment
- Quality assurance environment
- Production environment

The test and development environment is accessible for external developers using VPN (Virtual Private Network), so applications can be tested in an integrative data center environment very similar to the production environment, which is especially important, when different components from different software companies had to be combined.

The other two environments are completely managed by the data center operators. Only applications and updates which

passed the quality assurance process in the according environment is permitted to be transferred to the production environment.

Simultaneously with the publicly available information system about flood maps in Schleswig-Holstein developed by Disy the energy atlas started live operation for all state authorities at the end of 2014.

So these two applications form the first step within the MELUR service area in order to compose a data warehouse for the environmental and agricultural state authorities in Schleswig-Holstein. Based on this step the further conceptual development of the MELUR service area architecture will take place.

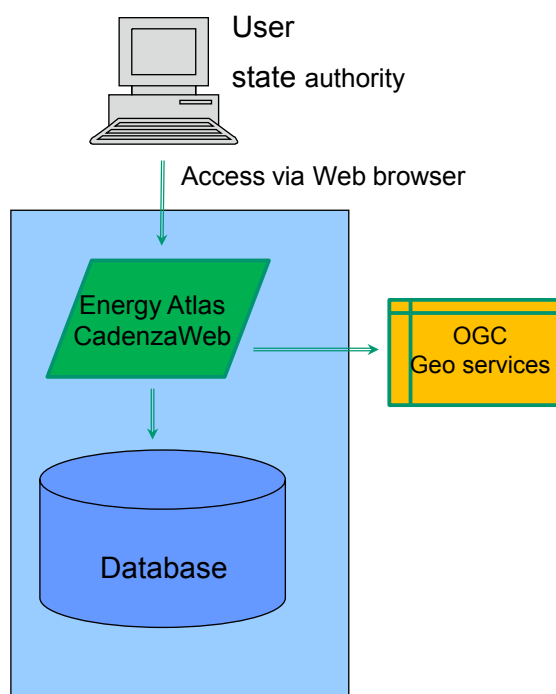


Fig. 6. State authorities can access the energy atlas using a web browser

IV. CONCLUSION AND OUTLOOK

With the development of the energy atlas a flexibly extensible instrument was created supporting Schleswig-Holstein's state authorities using existing immission control data to be researched, evaluated, and visualized in the context of the ongoing energy transition towards renewable energy supply.

The realization of the energy atlas provides a pilot application in proving the process model according to the

MELUR's data warehouse framework which can serve as a sample for integration of further applications into the MELUR service area in compliance with superordinate aims of the central IT management of the state administration.

In difference to [6] the energy atlas Schleswig-Holstein has currently its main focus on the evaluation of data about existing power plants while at the moment further energy potentials could not be offered by the system based on sound data.

Because the energy atlas is a first step to cover the combined renewable energy information, it mainly addresses the state authorities in supporting their official tasks. Further development steps will make a version available to the public, thus to be integrated in the state's energy portal site (<http://www.schleswig-holstein.de/Energie/>).

Moreover, additional relevant data acquired by the administrative district governments during their permission processes of energy plants, concerning for instance smaller wind turbines, should be incorporated in the energy atlas in the future. Another prospective information layer could be represented by data about the energy grid.

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Environmental labelling of electronic products: mobile phones, laptop and tablet

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Abstract—Electronic retailing is continually growing and evolving. New innovations such as 4G LTE network, supersized curved screens, laptops thinner and lighter than ever or connected devices stimulate consumer demand. Most people are unaware of the potential negative impact of the rapidly increasing use of electronic devices, for example, increasing scarcity of natural resources, world air cargo traffic growth, and difficulty of recycling. With the worldwide sales reaching 1.86 billion devices in 2014 only for mobile phone market, the ecological footprint of an electronic device may be small, but the cumulative effect is to be quite significant on a global scale. To reduce these impacts, consumers play a central role in sustainable production by purchasing eco-friendly products.

With this in mind, FNAC, a major French cultural and electronic device retailer, has launched in 2015 the environmental labelling of three product categories: mobile phone, laptop and tablet. This eco-rating scheme is based on a life cycle approach and distinguishes devices according to two indicators: global warming potential (kg CO₂ eq.), and abiotic resource depletion elements (kg Sb eq.). In order not to recreate something that already existed, the use of the “Mobile phone Product Category Rules” developed by the French environmental labelling program as a basis for its labelling scheme was decided. In this context, this project had to meet three challenges: How to participate in the improvement of the “Mobile phone Product Category Rules”? How to implement this methodology for two additional categories: laptop and tablet? And what communication formats are to be adopted to arouse the consumer interest?

This article presents the main results of the environmental labelling scheme developed by Hop-Cube, with the technical support of Bureau Veritas CODDE. First of all, this article addresses various modifications to improve the “Mobile phone Product Category Rules” to take into account the new technological evolutions of mobile phones. Based on the results of an LCA study of 7 mobiles phones, we show that environmental impacts are mainly due to the production of the screen and integrated circuits (processor, wireless broadband network and flash memory). The OLED technology used for the production of screen is a significant environmental aspect in comparison to the LCD technology (+20% on global warming between OLED and LCD mobiles). In addition, the use of chips based on gallium arsenide (GaAs) instead of silicon (Si) for the production of LTE network integrated circuits is a significant environmental aspect on global warming (+50% between 1cm² GaAs chip and 1cm² Si chip mobiles). Therefore, the impacts of the other components are less important and may be simplified. The next improvement

area should focus on the impact of data hosting and exchange of data.

Secondly, this article summarizes the methodological transposition for two new product categories: laptop and tablet. Based on the results of an LCA study of 3 laptops and 2 tablets, we show that environmental profiles of these two categories are similar to that of mobile phones: the production of screen is the main contributor. From this, the energy consumption for the production of the screen should be a primary data.

Finally, this article details the challenges regarding the choice of communication formats. Three communication formats have been retained for the environmental labeling: paper labels in stores, digital labels in stores using the screen of devices, and online posting on the website.

Key words — Environmental labelling, mobile phones, laptop, tablets, retailers.

I. INTRODUCTION

Electronic retailing is continually growing and evolving. New innovations such as 4G LTE (Long Term Evolution) network, supersized curved screens, laptops thinner and lighter than ever or connected devices stimulate consumer demand. Most people are unaware of the potential negative impact of the rapidly increasing use of electronic devices, for example, increasing scarcity of natural resources, world air cargo traffic growth, and difficulty of recycling. With the worldwide sales reaching 1.89 billion devices in 2014 [1] only for mobile phone market, the ecological footprint of an electronic device may be small, but the cumulative effect is to be quite significant on a global scale. To reduce these impacts, consumers play a central role in sustainable production by purchasing eco-friendly products.

With this in mind, FNAC [2], a major French cultural and electronic device retailer, has launched in 2015 the environmental labelling of three product categories: mobile phone, laptop and tablet. This eco-rating scheme is based on a life cycle approach through the recommendations defined by the French environmental labelling programs (general environmental footprint methodology BPX 30-323 [3]). The FNAC eco-rating distinguishes devices according to two indicators: global warming potential (GWP) (kg CO₂ eq.,

IPCC 2007 [4]), and abiotic resource depletion elements (ARDe) (kg Sb eq., CML 2002 [5]). In order not to recreate something that already existed, the use of the “Mobile phone Product Category Rules” [6] developed by the French environmental labelling program as a basis for its labelling scheme was decided. In this context, this project had to meet three challenges: How to participate in the improvement of the “Mobile phone Product Category Rules”? How to implement this methodology for two additional categories: laptop and tablet? And what communication formats are to be adopted to arouse the consumer interest?

This article presents the main results of the environmental labelling scheme developed by Hop-Cube, with the technical support of Bureau Veritas CODDE. First of all, this article addresses various modifications to improve the “Mobile phone Product Category Rules” to take into account the new technological evolutions of mobile phones. Secondly, it summarizes the methodological transposition for two new product categories: laptop and tablet. Finally, this article details the challenges regarding the choice of communication formats. The results of this study are based on 12 exclusive LCA studies: 7 mobiles phones, 3 laptops and 2 tablets.

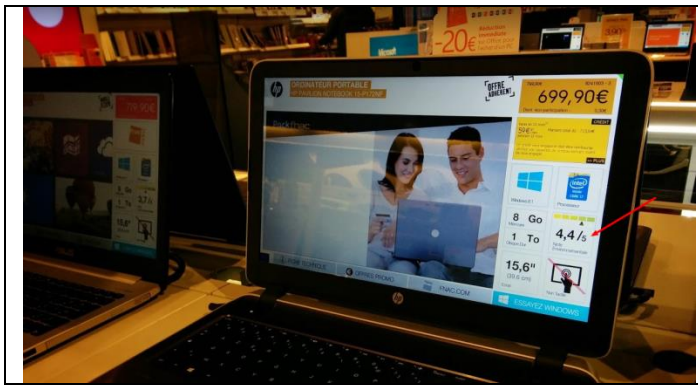


Fig. 1. Illustration of the FNAC's environmental labelling in France

II. PRESENTATION OF FNAC'S ENVIRONMENTAL LABELLING FOR MOBILE PHONES

A. Mobile phones: Functional unit & System boundaries

The FNAC's environmental labelling for mobiles is based on the application of the French environmental labelling program: general environmental footprint methodology BPX 30-323 [3] and “Mobile phone Product Category Rules” [6].

The studied products for this environmental labelling scheme are all mobile phones sold by FNAC in France. The reference unit includes: handset, battery, battery charger, headset, user manual, packing box, plastic films.

The mains functions of a mobile phone are sending and receiving data through the communication network (mobile phone network or internet). The functional unit is: “Using a mobile phone during 2 years in France”.

In accordance with French environmental labelling program, the total life cycle is taken into account and includes the production, distribution, use and end of life phases of tablets. For each phase of the life cycle, we will consider the

following steps: production of raw materials; logistics processes; water and energy consumption linked to the production processes; air emissions; water emissions; production cut-offs and waste (when known); treatment of waste and production cut-offs. However, the following flows have been excluded from the study:

- Building and running of telephone / internet network. This will be identical whatever the type of mobile phone. Hence they will have no influence on the comparison.
- The removal and repair of mobile phones (under guaranteed) to the customer service.
- Accessories, except headset and battery charger, are not considered.

B. Generic model for mobile phones

The generic model for mobile phones defined by the French environmental labelling program model takes into account 54 parameters (23 primary data¹, 24 semi-specific data² and 9 data to check the consistency of primary data): 43 for the manufacturing phase, 5 for the distribution phase, and 6 for the use phase.

The generic model for tablet is applicable for the scope defined in the table 1.

TABLE 1. SCOPE OF THE GENERIC MODEL FOR MOBILE PHONE

Technical parameter	Unit	Value of the parameter	
		Min	Max
Weight the mobile phone with battery	g	60	200
Type of screen	N/A	LCD ; LCD tactile	
Surface of screen	cm ²	7 cm ² (1,5'')	120 cm ² (6,5'')
Internal flash memory	Go	0	64

C. LCA of an average mobile phone

In this study, we calculated the environmental impacts of an average mobile phone from the “Mobile phone Product Category Rules” and a panel of 7 handsets representative of the market in 2014 and retailed by FNAC [7]. The LCAs are conducted using the EIME v5 software, the ELCD database and the EIME database (April 2014) [8]. The LCA results are presented in the table 2.

TABLE 2. ENVIRONMENTAL IMPACTS OF THE AVERAGE MOBILE PHONE

« Use a mobile phone for 2 years in France »				
	ARDe		GWP	
	kg Sb eq.	%	kg Sb eq.	%
1. Manufacturing	5.15e-2	99.9	4.20e+1	84.9
Battery	2.96e-5	0.1	2.96e-5	0.1
Charger	3.32e-3	6.4	3.32e-3	6.5
Printed wired board	1.40e-4	0.3	1.40e-4	0.3
Components <12 pins	6.99e-4	1.4	6.99e-4	1.4
Components >12 pins	8.15e-4	1.6	8.15e-4	1.6
Casing	1.65e-6	<0.1	1.65e-6	<0.1
Screen	4.59e-2	88.9	4.59e-2	88.9

¹ Primary data: data measured or determined by the manufacturer

² Semi-specific data: data proposed by default that the manufacturer can replace by primary data

<i>Fixed elements</i>	6.59e-4	1.3	6.59e-4	1.3
<i>Others</i>	0.00e+0	<0.1	0.00e+0	<0.1
<i>Air transport</i>	8.25e-8	<0.1	8.25e-8	<0.1
2. Distribution	2.26e-6	<0.1	2.26e-6	<0.1
3. Installation	0.00e+0	<0.1	0.00e+0	<0.1
4. Use	3.97e-5	<0.1	3.97e-5	0.1
5. End of life	4.53e-8	<0.1	6.62e-1	1.3
Sum	5.16e-2	100.0	4.95e+1	100.0

D. Ways of improvement for French environmental labelling program

Based on the “Mobile phone Product Category Rules” [6], Bureau Veritas CODDE has identified the need of 2 sensitivity analyses:

- **Type of screen:** a sensitivity analysis has been realised about the type of screen with 3 new technologies: touchscreen LCD, OLED and touchscreen OLED.
- **GaAs chips for components of more than 12 pins:** more and more electronic chip are based on gallium arsenide (GaAs) instead of silicon (Si), particularly the production of LTE network integrated circuits (WiFi and 3G/4G connection function). In 2013, 90% of mobile phones included LTE integrated circuits based on GaAs [9]. A sensitivity analysis was performed replacing 1cm² of silicon chip by 1cm² of GaAs chip in the average mobile phone.

TABLE 3. RESULTS OF SENSITIVITY ANALYSES FOR MOBILE PHONE CATEGORY

« Using a mobile phone during 2 years in France »				
	ARDe		GWP	
	kg Sb eq.	%	kg Sb eq.	%
Average mobile phone (Reference)	5.16e-2	100.0	4.95e+1	100.0
1. Type of screen				
Average mobile phone with touchscreen LCD	1.75e-1	+240.1	5.25e+1	+6.1
Average mobile phone with OLED	5.09e-2	-1.3	5.97e+1	+20.6
Average mobile phone with touchscreen OLED	1.74e-1	+238.4	6.46e+1	+30.5
2. Components >12 pins				
Average mobile phone with 1cm ² of GaAs chip	6.60e-2	+27.9	7.46e+1	+50.7

The 1st sensitivity analysis shows that the type of screen technology has a significant variation on the 2 environmental indicators. The OLED technology used for the production of screen is a significant environmental aspect in comparison to the LCD technology (+20% on global warming between OLED and LCD mobiles). The production of touchscreens has a strong impact on the abiotic resources depletion elements due to use of ITO nano particles. ITO is a ternary composition of Indium, Tin and Oxygen often used to make transparent conductive coatings for displays. Consequently for the FNAC's environmental labelling, we expand the choice of the type of screen by adding OLED technology and touchscreen OLED technology. LCD and touchscreen LCD technologies are already available in the “Mobile phone Product Category Rules” [6].

The 2nd sensitivity analysis shows that the use of chips based on gallium arsenide (GaAs) instead of silicon (Si) for the production of LTE network integrated circuits is a significant environmental aspect on global warming (+50% between 1cm² GaAs chip and 1cm² Si chip mobiles). Bureau Veritas CODDE will propose to consider this aspect in the review of the “Mobile phone Product Category Rules” [6].

III. PRESENTATION OF FNAC'S ENVIRONMENTAL LABELLING FOR TABLETS

A. Methodological transposition for two new product categories: tablet and laptop

In the French environmental labelling program, there are no Product Category Rules for tablet or laptop. To develop two new environmental labelling, Bureau Veritas CODDE used the general environmental footprint methodology BPX 30-323 [3] and LCA standardisation process. This approach (Fig. 3.) has been used to develop the SFR's Environmental labelling of mobile phones [10].

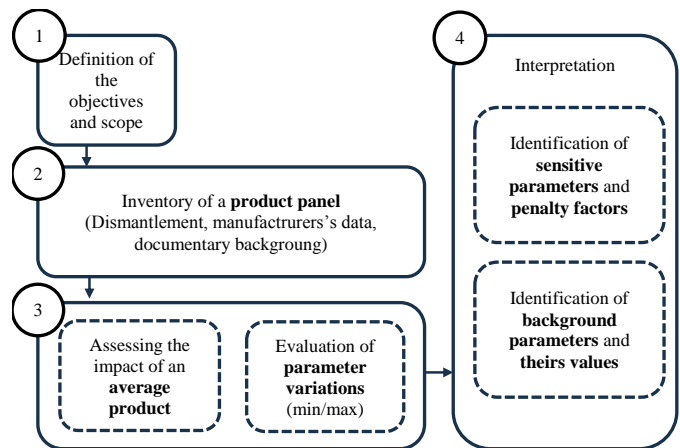


Fig. 2. LCA methodology used to develop new product category

The **assessment of an average product**, made from a product panel, allows defining the environmental profile of a new product category. Each parameter defining the average product has a minimum and maximum value to reflect the diversity of products within the category studied. The **evaluation of parameters variations** allows identifying **sensitive parameters** that will be considered as primary or semi-specific data in our methodology. Primary data are data measured or calculated by the manufacturer. Semi-specific data are data proposed by default (**penalty factors**) in order to replace primary data when primary data are unknown. Other parameters, having small variation on environmental impacts between products, are **background parameters** that is to say secondary data³. Secondary data are average data used whatever the product.

For each product category, we have:

³ Secondary data: average data used regardless of the manufacturer

- A **questionnaire** aimed to manufacturers with penalty factors in case of non-response
- A **generic model** to perform the LCA based on this questionnaire

B. Tablets: Functional unit & System boundaries

Studied products for this environmental labelling scheme are all tablets sold by FNAC in France. The reference unit includes: tablet, keyboard (if applicable), battery, battery charger, user manual, packaging box, plastic films.

The main functions of a tablet are installing and running programs, and browsing the Internet. The tablet market is a new one appearing from the success of the Apple iPad tablet launched in early 2010. Currently there is no study that estimates the average lifetime of tablets in France. Given that the use of a tablet is between a laptop and a smartphone, Bureau Veritas CODDE proposes an average lifetime between the mobile phone and laptop categories: 3 years. For this product category, the chosen functional unit is: **“Using a tablet during 3 years in France”**. According to a MillwardBrown study [11], the average usage time of a tablet by French people is 30 minutes a day. We considered that the remaining time the tablet is in sleep mode. There is no sensitivity analysis on the average usage time.

In accordance with the BPX 30-323 [3], the total life cycle is taken into account and includes the production, distribution, use and end of life phases of tablets. For each phase of the life cycle, we will consider the following steps: production of raw materials; logistics processes; water and energy consumption linked to the production processes; air emissions; water emissions; production cut-offs and waste (when known); treatment of waste and production cut-offs.

Specifically to the tablet category, the following flows have been excluded from the study:

- Building and running of telephone / internet network. These will be identical whatever the type of tablet. Hence they will have no influence on the comparison.
- Removal and repair of tablets (under guaranteed) to the customer service.
- Accessories, except hybrid keyboard and battery charger, are not considered.

C. LCA of an average tablet

For this study, we calculated the environmental impacts of an average tablet from a panel of 2 tablets representative of the market in 2014 [12]. The LCAs are conducted using the EIME v5 software, the ELCD database and the EIME database (April 2014) [8]. The LCA results are presented in the table 4.

TABLE 4. ENVIRONMENTAL IMPACTS OF THE AVERAGE TABLET

« Using a tablet during 3 years in France »				
	ARDe		GWP	
	kg Sb eq.	%	kg Sb eq.	%
1. Manufacturing	1.52e+0	99	7.27e+1	80.1
Battery	1.30e-4	<0.1	8.48e+0	3.5
Charger	6.12e-3	0.4	8.83e-1	0.4
Printed wired board	4.68e-4	<0.1	1.49e+0	0.6
Keyboard	1.31e-4	<0.1	2.18e+0	0.9
Components <12 pins	1.13e-3	0.1	1.77e+0	0.7

Components >12 pins	6.80e-4	<0.1	1.83e+0	0.8
Casing	6.89e-6	<0.1	1.23e+0	0.5
Screen	1.52e+0	99.4	1.84e+2	72.6
Fixed elements	5.85e-4	<0.1	2.44e-1	0.1
Others	8.78e-9	<0.1	1.68e-3	<0.1
Air transport	3.70e-8	<0.1	1.59e-1	0.1
2. Distribution	9.93e-6	<0.1	3.39e+1	13.5
3. Installation	0.00e+0	<0.1	0.00e+0	<0.1
4. Use	3.89e-4	0.1	1.43e+1	10.6
5. End of life	-4.20e-7	<0.1	3.38e-1	0.3
Sum	1.53e+0	100.0	2.51e+2	100.0

D. Sensitivity analysis

In this paragraph, we want to identify the parameters allowing distinguishing tablets. We considered a variation of +/-20% compared to the average tablet is significant. We identified 16 sensitivity analyses. The results of these sensitivity analyses are shown in the table 5.

TABLE 5. RESULTS OF SENSITIVITY ANALYSES FOR TABLET CATEGORY

« Use a tablet for 3 years in France »				
	ARDe		GWP	
	kg Sb eq.	%	kg Sb eq.	%
Average tablet (Reference)	1,53E+00	100.0	2,51E+02	100.0
1. Weight of tablet				
0,5 * weight of average tablet	7,25E-01	-52.6	1,41E+02	-43.8
1,8 * weight of average tablet	2,73E+00	+78.4	4,04E+02	+61.0
2. Screen				
Touchscreen OLED screen	1,52E+00	-0.7	3,62E+02	+44.2
7'' screen	9,53E-01	-37.7	1,82E+02	-27.5
12'' screen	2,78E+00	+82	4,04E+02	+61.0
3. Keyboard				
Without keyboard	1,53E+00	< -0.1	2,45E+02	-2.4
4. Battery				
0,7 * weight of average battery	1,53E+00	< -0.1	2,46E+02	-2.0
5. Casing				
0,7 * weight of average casing	1,53E+00	< -0.1	2,49E+02	-0.8
6. Charger				
0,8 * weight of average charger	1,53E+00	< -0.1	2,50E+02	< -0.1
7. Components >12 pins				
2 * surface of average integrated circuits	1,53E+00	< +0.1	2,54E+02	+1.2
0,5 * surface of average printed wired boards	1,52E+00	-0.7	2,38E+02	-5.2
+ 64 Go internal flash memory (31 cm ² of silicon chip)	1,53E+00	< +0.1	4,20E+02	+67.3
8. Use phase				
0,5 * power consumption of average tablet	1,53E+00	< -0.1	2,38E+02	-5.2
9. Distribution				
2 * distance of distribution	1,53E+00	< +0.1	3,13E+02	+24.7
Ship (Chine > France) instead plane	1,53E+00	< -0.1	1,89E+02	-24.7
Road (Chine > France) instead plane	1,53E+00	< -0.1	1,90E+02	-24.3

For the tablet category, these sensitivity analyses show that:

- The production of the screen is the main contributor to environmental impacts. It depends of the screen surface, but also the screen technology. The variation of impacts between touchscreen LCD technology and touchscreen OLED technology is significant.
- The density of components, relatively uniform, allows creating a single parameter for printed wired board

and electronic components. The set “printed wired board and electronic components” depends on the total surface of the printed wired boards and the total surface of silicon chips. The parameter “surface of silicon chips” can meet the demand in terms of storage capacity variations and processor power.

- The metal and plastic components have a low mass change on the panel, and induce a small change in environmental impacts.
- The presence or absence of detachable keyboard has a small impact on the variation of environmental impact results.
- The presence of additional chips in silicon, resulting in a larger storage capacity, has a significant influence on global warming potential.
- Changing the baseline scenario for the use phase induces a relatively small variation of environmental impacts.
- The distribution (distance and mode of transport) has a strong impact on global warming potential.

E. Generic model for tablet

Thanks to the previous results, an LCA generic model for tablet has been defined. This LCA generic model takes into account 17 variables (12 primary data and 5 semi-specific data): 12 for the manufacturing phase, 3 for the distribution phase, and 2 for the use phase.

TABLE 6. LIST OF PRIMARY AND SEMI-SPECIFIC DATA FOR TABLET CATEGORY

N°	Parameter	Unit	Primary data	Semi-specific data
1	Total weight with packaging, Weight	g	✓	
2	Total weight without packaging, Weight	g	✓	
3	Display panel, Type	N/A	✓	
4	Display panel, Active surface area of the display panel	cm ²	✓	
5	Display panel, Production energy consumption	kWh		✓
6	Printed circuit boards, Provide the external area of the printed circuit boards.	cm ²	✓	
7	Integrated circuits over 12 connexions (semi-conductors over 12 connexions), Integrated circuit area	cm ²	✓	
8	Flash memory capacity for data storage	Go	✓	
9	Integrated circuits over 12 connexions (semi-conductors over 12 connexions), Silicon chip area	cm ²		✓
10	Casing, Weight	g	✓	
11	Battery, Weight	g	✓	
12	Is there any keyboard with your tablet?	g	✓	
13	Transport (from assembly to customisation site), Plane	km		✓
14	Transport (from assembly to customisation site), Ship	km		✓
15	Transport (from assembly to customisation site), Lorry	km		✓
16	Power consumption in active mode	W	✓	
17	Power consumption in stand-by mode	W	✓	

The generic model for tablet is applicable for the scope defined in the table 7.

TABLE 7. SCOPE OF THE GENERIC MODEL FOR TABLET

Technical parameter	Unit	Value of the parameter	
		Min	Max
Total weight of tablet with battery	g	640	2 000
Type of screen	N/A	Touchscreen LCD ; Touchscreen OLED	
Surface of screen	cm ²	135 cm ² (7'')	400 cm ² (12'')
Internal flash memory	Go	32	128
Keyboard	N/A	No	Yes

IV. PRESENTATION OF FNAC'S ENVIRONMENTAL LABELLING FOR LAPTOPS

A. Laptops: Functional unit & System boundaries

Studied products for this environmental labelling scheme are all laptops sold by FNAC in France. The reference unit includes: laptop, battery, battery charger, user manual, packaging box, plastic films.

The mains functions of a laptop are installing and running programs, and browsing the Internet. According to two studies [13] [14] the lifetime of a computer in France is 4.67 years with a lifetime between 3 to 4 years for a laptop and a lifetime between 5 and 6 years for a desktop computer. In consultation with Hop-Cube team, Bureau Veritas CODDE proposes a 4-year lifetime for the laptop category. For this product category, the chosen functional unit is: **“Using a laptop during 4 years in France”**. According to the ErP preparatory study [15], the average utilization time of a laptop is 1,388 hours per year in active mode, 2,904 hours per year in stand-by mode and 4,468 hours per year in off mode. There is no sensitivity analysis on the average usage time.

In accordance with the BPX 30-323 [3], the total life cycle is taken into account and includes the production, distribution, use and end of life phases of tablets. For each phase of the life cycle, we will consider the following steps: production of raw materials; logistics processes; water and energy consumption linked to the production processes; air emissions; water emissions; production cut-offs and waste (when known); treatment of waste and production cut-offs.

Specifically to the laptop category, the following flows have been excluded from the study:

- Building and running of internet network. This will be identical whatever the type of laptop. Hence they will have no influence on the comparison.
- Removal and repair of laptops (under warranty) to the customer service.
- Accessories are not considered.

B. LCA of an average laptop

For this study, we calculated the environmental impacts of an average tablet from a panel of 3 laptops representative of the market in 2014 [16]. The LCAs are conducted using the EIME v5 software, the ELCD database and the EIME database (April 2014) [8]. The LCA results are presented in the table 8.

TABLE 8. ENVIRONMENTAL IMPACTS OF THE AVERAGE LAPTOP

« Using a laptop during 4 years in France »				
	ARDe		GWP	
	kg Sb eq.	%	kg Sb eq.	%
1. Manufacturing	6.85e-1	99.9	2.82e+2	73.5
Power supply	3.98e-2	5.9	4.88e+0	1.3
Battery	2.31e-4	<0.1	1.51e+1	4.0
Charger	3.98e-2	5.9	4.88e+0	1.3
Printed wired board	1.39e-3	0.2	4.12e+0	1.1
Keyboard	1.25e-5	<0.1	1.08e+0	0.3
Components <12 pins	5.18e-3	0.8	8.63e+0	2.3
Components >12 pins	3.20e-3	0.5	8.60e+0	2.3
Casing	3.07e-5	<0.1	5.04e+0	1.3
Hard drive	4.31e-3	0.7	3.14e+0	0.8
Screen	6.29e-1	91.7	2.30e+2	59.8
Fixed elements	5.85e-4	0.1	2.44e-1	0.1
CD player	8.83e-4	0.1	8.78e-1	0.2
Others	3.16e-7	<0.1	6.05e-2	<0.1
Road transport	8.33e-8	<0.1	3.59e-1	0.1
Fan	5.18e-5	<0.1	2.09e-1	0.1
2. Distribution	1.70e-5	<0.1	6.50e+1	17.1
3. Installation	0.00e+0	<0.1	0.00e+0	<0.1
4. Use	9.58e-4	0.1	3.52e+1	9.2
5. End of life	-9.22e-8	<0.1	7.12e-1	0.2
Sum	6.86e-1	100.0	3.83e+2	100.0

C. Sensitivity analysis

In this paragraph, we want to identify the parameters allowing distinguishing laptops. We considered a variation of +/-20% compared to the average laptop is significant. We identified 18 sensitivity analyses. The results of these sensitivity analyses are shown in the table 9.

TABLE 9. RESULTS OF SENSITIVITY ANALYSES FOR LAPTOP CATEGORY

« Use a laptop for 4 years in France »				
	ARDe		GWP	
	kg Sb eq.	%	kg Sb eq.	%
Average laptop (Reference)	6.86e-1	100.0	3.83e+2	100.0
1. Weight of laptop				
0,5 * weight of average laptop	5.43E-01	-20.8	3.01E+02	-21.3
1,5 * weight of average laptop	1.00E+00	+46.2	5.38E+02	+40.6
2. Screen				
OLED screen	6.59E-01	-0.4	5.25E+02	+37.2
Touchscreen LCD screen	2.41E+00	+250.8	4.27E+02	+11.5
Touchscreen OLED screen	2.39E+00	+249.0	5.93E+02	+54.9
10" screen	5.76E-01	-16.0	3.42E+02	-10.8
19" screen	1.04E+00	+52.1	5.17E+02	+35.1
4. Battery				
0,7 * weight of average battery	6.80E-1	< -0.1	3.42E+02	-1.6
5. Casing				
0,7 * weight of average casing	6.80E-1	< -0.1	3.43E+02	-1.5
6. Power supply				
0,8 * weight of average power supply	6.79E-01	-1.0	3.80E+02	-0.8
7. Hard drive				
0,9 * weight of average hard drive	6.85E-01	-0.1	3.82E+02	-0.2
8. Components >12 pins				
2 * surface of average integrated circuits	6.89E-01	+0.4	3.91E+02	+2.2
0,5 * surface of average printed wired boards	6.31E-01	-0.8	3.71E+02	-3.1
+ 256 Go internal flash memory (124 cm² of silicon chip)	6.77E-1	-0.1	7.42E+02	+93.7
9. Use phase				

0,5 * power consumption of average laptop	6.38E-01	-0.7	3.65E+02	-4.6
10. Distribution				
2 * distance of distribution	6.80E-1	< +0.1	4.48E+02	+16.9
Ship (Chine > France) instead plane	6.79E-01	-0.1	3.19E+02	-16.8
Road (Chine > France) instead plane	6.79E-01	-0.1	3.20E+02	-16.5

For the laptop category, these sensitivity analyses show that:

- The production of the screen is the main contributor to environmental impacts. It depends of the screen surface, but also the screen technology (LCD, touchscreen LCD, OLED and touchscreen OLED).
- The density of components, relatively uniform, allows creating a single parameter for printed wired board and electronic components. The set “printed wired board and electronic components” depends on the total surface of the printed wired boards and the total surface of silicon chips. The parameter “surface of silicon chips” can meet the demand in terms of storage capacity variations and processor power.
- The metal and plastic components have a low mass change on the panel, and induce a small change in environmental impacts.
- The presence of additional chips in silicon, resulting in a larger storage capacity, has a significant influence on global warming potential.
- Changing the baseline scenario for the use phase induces a relatively small variation of environmental impacts.
- The distribution (distance and mode of transport) has a strong impact on global warming potential.

D. Generic laptop evaluation model

Thanks to the previous results, an LCA generic model for laptop has been defined. This LCA generic model takes into account 18 variables (12 primary data and 6 semi-specific data): 13 for the manufacturing phase, 3 for the distribution phase, and 2 for the use phase.

TABLE 10. LIST OF PRIMARY AND SEMI-SPECIFIC DATA FOR LAPTOP CATEGORY

N°	Parameter	Unit	Primary data	Semi-specific data
1	Total weight with packaging, Weight	g	✓	
2	Total weight without packaging, Weight	g	✓	
3	Display panel, Type	N/A	✓	
4	Display panel, Active surface area of the display panel	cm²	✓	
5	Display panel, Production energy consumption	kWh		✓
6	Printed circuit boards, Provide the external area of the printed circuit boards.	cm²	✓	
7	Integrated circuits over 12 connexions (semi-conductors over 12 connexions), Integrated circuit area	cm²	✓	
8	Flash memory capacity for data storage	Go	✓	
9	Integrated circuits over 12 connexions (semi-conductors over 12 connexions), Silicon chip	cm2		✓

	area			
10	Casing, Weight	g	✓	
11	Battery, Weight	g	✓	
12	Is there any hard drive in the computer?	g	✓	
13	Transport (from assembly to customisation site), Plane	km		✓
14	Transport (from assembly to customisation site), Ship	km		✓
15	Transport (from assembly to customisation site), Lorry	km		✓
16	Power consumption in active mode	W	✓	
17	Power consumption in stand-by mode	W	✓	
18	Power consumption in off mode	W	✓	

The generic model for laptop is applicable for the scope defined in the table 11.

TABLE 11. SCOPE OF THE GENERIC MODEL FOR LAPTOP

Technical parameter	Unit	Value of the parameter	
		Min	Max
Total weight of laptop with battery	g	2 000	3 000
Type of screen	N/A	LCD; OLED; Touchscreen LCD ; Touchscreen OLED	
Surface of screen	cm ²	275 cm ² (10'')	1 100 cm ² (19'')
Internal flash memory	Go	1 (there is hard drive)	512

V. COMMUNICATION FORMATS OF FNAC'S ENVIRONMENTAL LABELLING

A. Context

The demand for sustainable impact information on products is unprecedentedly growing. In Europe for instance, it is considered that 69% of citizens support governments to make companies publish reports on their environmental performance [17]. The impact and consequences of a wide range environmental labelling project are therefore substantial.

For its own project FNAC's goals are the following:

- The environmental information that is displayed on the product has to take into account the entire life cycle of the product. This means that not only shall the label be based on LCA, but also all LCA related information has to be accessible for the end-consumer. Transparency is therefore a key constraint
- The label has to be understandable by non-experts (non-experts include both consumers and FNAC's sellers).
- Non-experts have to be able to compare products one to another
- Environmental information has to be displayed on a maximum of products, if not all products sold by the retailer (within the categories of products described earlier).

Besides, the label has to be flexible enough to change if it is not understood correctly. That is why consumers' interest and

behavior over the label are measured regularly. Statistic reports have revealed that since it has started, the environmental labelling project for televisions (the first category of product that was concerned by an environmental label at FNAC) has gathered more than 10 millions views on FNAC's website. No in-stores studies have been conducted yet, but feedbacks from sellers have been collected. They have shown mainly that end-consumers are looking for the information in stores: environmental footprint is becoming key information in the buying process.

B. Gathering the required data

Such an environmental labelling project needs regular data information to cover all products sold by FNAC, which have a high turnover (every month around a hundred new products are presented to consumers).

To do so, Hop-Cube maintains an up-to-date database of all products available on the market (not only FNAC's products), thanks to an automated software called HopMedia. This unique database enables Hop-Cube to compute a global rating out of 5 on each product. This score helps non-experts to understand whether the LCA's results are significant or not, according to other products on the market. It also helps retailers like FNAC to better understand where the products they sell stand according to environmental standards.

One might argue that ABCD scores are more efficient than scores out of 5. However this format was already chosen for FNAC's televisions and televisions in Europe already have an EU Energy Label with the ABCD format. The score out 5 enables then to understand that there is a difference at first glance with the Energy Label. Of course the comparison between an environmental labelling project and an energy labelling project might still seem unclear for a first time viewer. That is also why FNAC sellers have been included in the project since the beginning, in order for sellers to be able to answer questions in stores.

To sum it up, by using this unique score, FNAC has reached its comparison and educational objectives. The only important objective missing at this point is transparency, and with it, the whole concept of life cycle analysis that might not be understandable by looking at the score only.

C. Shaping a label that fits with FNAC's strategy

Hop-Cube sustainable marketing experts have proposed a graphic design and some educational best practices to shape an environmental label compliant with FNAC's marketing strategy and with the educational constraints described earlier. The final label thus declined itself in two different sizes depending on its final location:

- A **short version**, showing only the score, compliant with the small place left on price labels:



Fig. 2. Illustration of FNAC's environmental labelling in stores

Depending on the level of the score, the score is displayed with a color which goes from green (high environmental efficiency score according to the market) to yellow (low efficiency score according to the market). This short version was created only for in-stores labelling, educational and more detailed content being given by sellers themselves. As mentioned earlier, special courses are provided to sellers so they are able to explain the environmental labelling to consumers. If needed, they can use as well the web content described below.

- **Digital labelling** means usually unlimited space for content. At first, one might think that this advantage will enable full transparency and educational content easily. This has to be counterbalanced by the following constraints:
 - o There is already a lot of information to display on a product
 - o Putting too much information at once might be frightening for the consumer
 - o Showing little information might not help the consumer to trust the information displayed

Thus, Hop-Cube has developed the web label as a widget:



Fig. 3. Illustration of FNAC's environmental labelling on the web

This technology has several benefits:

- The information presented is linked with the product the consumer is looking at
- It enables several reading levels with a pop-in window (the consumer stays on the retailers' website)
- It is easy to set-up for the retailer, and it can be placed anywhere on a web page
- It can measure statistics on how the information is read by consumers

The following screenshot presents what happens after clicking on the e-commerce label/widget:

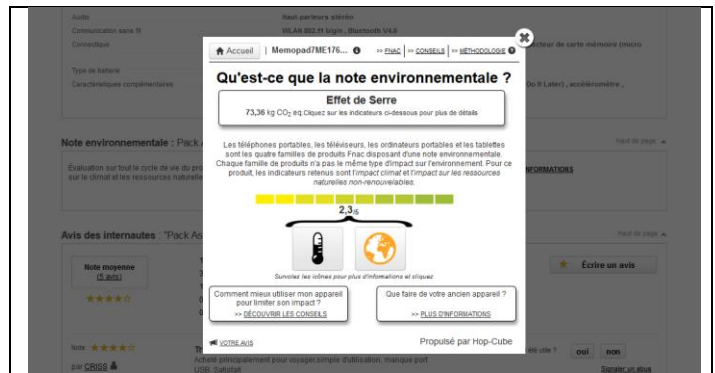


Fig. 4 Illustration of FNAC's environmental labelling in stores

By clicking on the widget, consumers access a pop-in page with general information on the environmental labelling project (especially the life cycle part) and shortcuts to other information:

- The description of the environmental impact indicators: what do they mean, what can they be compared to?
- Some advice on how to use the product better in order to limit its environmental impact (even if the most powerful actions are effective only for televisions and mobile phones)
- Information on what to do with their previous equipment if they are planning not to use this product anymore
- Information on how the single score was computed and how to use it / understand it
- A link to a PDF file explaining in more details the methodology
- Some explanation on FNAC's strategy and commitments towards sustainability in general (not only through environmental labelling)

Moreover, a suggestion box is presented as well. With this functionality, consumers are allowed to leave a message or questions that will be answered by Hop-Cube through direct email.

VI. CONCLUSION

FNAC's environmental labelling enables customers to compare the environmental performance of different electronic devices: televisions, mobiles phones, tablets and laptops. This eco-rating scheme is based on a life cycle approach through the recommendations defined by the French environmental labelling program and distinguishes devices according to two indicators: global warming potential (kg CO₂ eq.), and abiotic resource depletion elements (kg Sb eq.).

Bureau Veritas CODDE defined the LCA model for each product category.

The eco-rating for mobile phones is based on "Mobile phone Product Category Rules" defined by the French environmental labelling programs. In this study, we learned two points:

- OLED technology used for the production of screen is a significant environmental aspect in comparison to the LCD technology.
- The use of chips based on gallium arsenide (GaAs) instead of silicon (Si) for the production of LTE network integrated circuits is a significant environmental aspect on global warming. This point will be discussed in the revision of the "Mobile phone Product Category Rules".

To define the eco-rating for tablets and laptop, we used an LCA standardisation process based on a panel of tablets and laptops representative of the market. The generic model for tablet requires 17 variables whereas the generic model for laptop requires 18 variables. The variables are the same for both categories except for the laptop category which requires an additional variable about the hard driver.

Hop-Cube sustainable marketing experts have proposed a graphic design and some educational best practices to shape an environmental label compliant with FNAC's marketing strategy. The final label thus declined itself in two different sizes depending on its final location:

- A **short version**, showing only the score, compliant with the small place left on price labels.
- A **digital labelling**, showing the score, general information on the environmental labelling project and shortcuts to other information.

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Latest Developments of the Linked Thesaurus Framework for the Environment (LusTRE)

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Abstract— We present a solution for inter-linking domain thesauri and other controlled vocabularies represented as Linked Data content within the LusTRE framework. We discuss how such inter-linked content can help users to easier and better express and use thesauri and controlled vocabularies for metadata work within Spatial Data Infrastructures, at the concrete example of an INSPIRE-driven environmental use case. We present the Thesaurus Exploitation services designed and implemented for LusTRE and their integration with existing metadata editors and SDI geoportals.

Keywords—thesaurus management, thesaurus exploitation service, thesaurus inter-linking, linked open data, SKOS, metadata management, INSPIRE implementation

I. INTRODUCTION

The EU-FP7 CIP-PSP project eENVplus [3] aims at developing a complete ecosystem of software services for comprehensively supporting all aspects of interoperable environmental data in the Web. The software services are developed for and tested in ten INSPIRE and SEIS pilot implementation test-beds. INSPIRE¹ is the European Directive which pledges the EU member states to establish Web-based and service-oriented software infrastructure for spatial information to support Community environmental policies, and policies or activities which may have an impact on the environment. INSPIRE addresses 34 data themes (like cadastral parcels, hydrography, protected sites, agricultural+aquaculture facilities, sea regions, natural risk zones, etc.) needed for environmental applications, with key components specified through technical implementing rules. SEIS², the Shared Environmental Information System for Europe aims at better access to environment information for environment administration and politics, NGOs, academia and general public. The eENVplus pilot test-beds comprise, e.g., a cross-border pilot about everyday-life issues connected to environmental aspects in Czech Republic and Slovakia, a natural-areas INSPIRE-compliance toolbox in France, a cross-border pilot in Hungary and Slovakia about protected areas, a cross-border pilot in Italy and Slovenia about geological-map harmonization, etc.

For all the data published in such Spatial Data Infrastructures (SDIs) for the environment, *metadata* must be added

which describe general aspects of the actual data such as the creator, their up-to-dateness, their geographical coverage or keywords about their subject-matter. In order to “standardize” such content descriptions, keywords for subjects are normally taken from pre-defined thesauri or vocabularies. However, such pre-defined “Knowledge Organization Systems (KOS)” are often made for domain experts and cover only very narrow knowledge areas (but very deeply), they are mostly not translated in all European languages, and they adopt different viewpoints for structuring their concepts. Hence, although the different KOSs logically overlap and are related, this is normally very difficult to oversee for an end user – which leads to limited interoperability of metadata written with respect to different KOSs. Hence, as part of the eENVplus project, a thesaurus framework (LusTRE - Linked Thesaurus Framework for the Environment) is being developed and exemplarily filled which allows inter-linking of different KOSs (domain thesauri) in order to achieve a broader domain coverage, more multilinguality, and novel cross-domain thesaurus services when using KOSs for creating or editing metadata or for searching. The LusTRE framework and its associated exploitation services (LusTRE-ES) are designed as a stand-alone software infrastructure which can be called in a service-oriented manner by other software tools such as metadata editors or catalogue services.

Intermediate versions of the LusTRE framework and its exploitation services have already been presented in prior papers and talks (see, e.g. [1] or [2]). Now, coming close to the end of the project, we sketch the almost final status of the software developments. The presentation in this paper is directed towards an audience with prior knowledge, in the LusTRE work, the topic of thesauri in INSPIRE implementation, or technical details of thesaurus and/or metadata management.

This paper is structured as follows: In the next Section II, an overview of LusTRE system components and their interplay is given, including some abstract use cases illustrating the potential benefits for end users working with the tool. In Section III, the current status of LusTRE content is sketched. Section IV lists the available LusTRE Exploitation Services, illustrates one concrete service in more detail and briefly reviews the LusTRE-ES implementation. Section V describes the LusTRE web interface and the explorative tool functionalities offered to users for manual inspection of inter-

¹ <http://inspire.ec.europa.eu/>

² <http://ec.europa.eu/environment/archives/seis/>

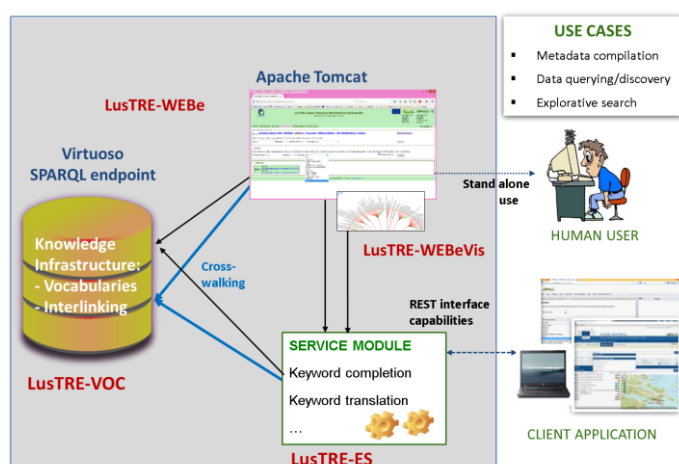


Figure 1: Overview of LusTRE Components

linked thesauri. Section VI mentions the tools which have already exemplarily been coupled to and enhanced by LusTRE-ES. Section VII concludes the paper with a short summary.

II. OVERVIEW OF LUSTRE COMPONENTS

Figure 1 illustrates the different elements of the LusTRE solution and their collaboration. The knowledge infrastructure of LusTRE is LusTRE-VOC. The LusTRE-VOC implementation is a Virtuoso instance. Virtuoso³ is a multi-purpose and multi-protocol data server which, among other functionalities, allows storing and querying RDF knowledge bases. RDF is the representation language of the Semantic Web for easily representing arbitrary knowledge structures. Virtuoso offers a SPARQL endpoint. SPARQL⁴ is the World Wide Web Consortium's (W3C) standard query language for RDF. The thesauri, ontologies, controlled vocabularies or code lists that we want to manage and link together in LusTRE are all different kinds of Knowledge Organization Systems. For such KOS, the "Simple Knowledge Organization System" (SKOS)⁵ has been proposed as the W3C standard way of representing in RDF. With SKOS, all thesaurus-relevant aspects can be expressed, such as concepts with different labels and translations of labels, broader and narrower relationships, more general relationships, etc. Further, the Semantic Web languages in general allow expressing that specific objects are identical ("matching statements"). Hence, our approach in LusTRE is to represent existing environmental KOS in the SKOS schema and inter-link them by matching statements. This general approach follows the Linked Open Data (LOD) paradigm pushed by the W3C since a couple of years.⁶ For doing so, all integrated thesauri must be expressed in SKOS format and all concepts represented by a dereferenceable URI. For some thesauri, such SKOS representations of existing KOSs have been created within the project and stored in LusTRE-VOC. But if a KOS is already published as SKOS following the LOD

principles, it can remain with the created and only the inter-linkings to such external sources must be represented in LusTRE-VOC. After the inter-linking of different environmental thematic vocabularies they can be accessed through the SPARQL endpoint as one virtual integrated linked data source.

In order to ease the use of the content contained in LusTRE, without knowing the technicalities of SPARQL and the underlying knowledge infrastructure, the LusTRE exploitation services (LusTRE-ES) have been implemented. LusTRE-ES, through a REST interface, offers a number of end-user oriented web services that can help with keyword management when working on one of the typical use cases: creating metadata for some web data resource in an SDI, querying or discovering web resources through metadata, or exploring the conceptual space spanned by resource metadata in order to browse the underlying knowledge, better understanding the application domain, etc. These LusTRE-ES services are implemented by a number of service modules that are coordinated by a central service manager. Concretely, such a service module takes a specific user request with the associated input parameters, formulated in terms appropriate for the end user functionality, and translates it into the appropriate SPARQL query to be evaluated against the LusTRE-VOC SPARQL endpoint. The service manager takes these SPARQL query/ies (sometimes, several service modules may be suitable for a given user request), hands them over to the Virtuoso server, collects the results, if necessary merges the results, and delivers the final result to the client. During the execution of the SPARQL query by the Virtuoso server, the cross-walking between different thesauri may happen – thus connecting different knowledge domains or bridging between different languages, etc.

Such clients which use the LusTRE-ES service interface to "pimp" their own functionalities with (linked) thesaurus knowledge, may, for instance, be metadata editors, catalogue services, or geoportals.

Besides this kind of "embedded" use of LusTRE, hidden behind the functionalities of another client software, a human user may also be interested in directly, manually exploring the inter-linked thesauri. To this end, the LusTRE-WEBE web interface has been built that allows, on one hand, manual browsing through the LusTRE vocabularies, and, on the other hand, calling the LusTRE-ES services directly. This web interface will also contain an enhanced visualization tool (LusTRE-WEBEVis) that facilitates graphical interaction with the thesaurus knowledge and illustrates the knowledge graphs and their interdependencies.

Abstract Use Cases.

In general, use cases for the provided functionalities can be sketched as follows:

- The LusTRE exploitation services can deliver to a search engine or to a metadata editor, the synonymous, broader, narrower or related terms of a keyword, taken from several inter-linked controlled vocabularies (KOSs) – which facilitates cross-domain, cross-corpus, cross-boundary and multilingual search as well as consistent and complete metadata annotation.

³ <http://www.w3.org/wiki/VirtuosoUniversalServer>

⁴ <http://www.w3.org/TR/rdf-sparql-query/>

⁵ <http://www.w3.org/2004/02/skos/>

⁶ <http://www.w3.org/wiki/LinkedData>

- For a user who is less experienced in some domain and who has to create or maintain metadata, the visualization service as well as visual browsing through conceptual spaces of several inter-linked thesauri, together with term explanations and term translations, can help to better understand and use the provided controlled vocabularies.
- The automated cross-walking between terms from different inter-linked KOSs supports easier working beyond the scope and limitations of a single vocabulary alone.

III. CONSOLIDATION OF THE LUSTRE CONTENT

During the last year, the set of included KOSs (ontologies, thesauri, code lists) has been extended (see Figure 2), as well as their inter-linking. In the meanwhile, the content in the LusTRE knowledge infrastructure covers all INSPIRE data themes. In particular, extensive and inter-linked vocabularies are available for the following data themes:

- PS (Protected Sites).
- BR (Biogeographical regions).
- HB (Habitat & Biotope).
- SD (Species Distribution).
- EF (Environmental Monitoring Facilities).
- SO (Soil).
- AQ (Air Quality).

Besides that, good language coverage and a good level of multilingualism have been reached.

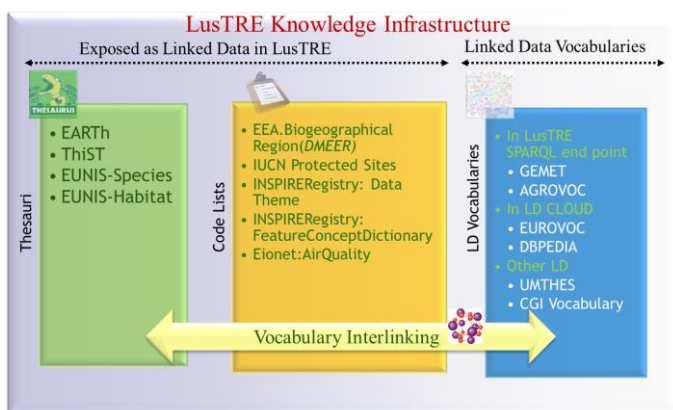


Figure 2: Overview of Controlled Vocabularies Currently Included in LusTRE

IV. AVAILABLE LUSTRE EXPLOITATION SERVICES

In the last year, the software services for using the thesaurus knowledge in metadata creation and information search (specified in [1]), have been fully implemented, extensively tested, and – based on user feedback – slightly extended and refined. Two additional parameters have been included which allow to better control the extent to which the conceptual space spanned by the inter-linked concepts in different controlled vocabularies, is really explored in concrete

queries to the LusTRE (for instance, when asking for synonymous, broader, narrower, or related terms). One new parameter allows focusing only on a specific subset of available thesauri when evaluating a request. The other new parameter allows switching on or off whether inter-thesaurus should really be used when evaluating a request (instead of restricting the search to concepts all contained in one specific thesaurus). The following services are offered to the end user or to any client application through the REST interface:

- **GetCapabilities:** Describes the services offered by this concrete LusTRE-ES instance. The response contains (1) service metadata; (2) operation descriptions for the implemented service modules, their operations and the parameters of these operations; and (3) descriptions of the thesauri exploited by this LusTRE-ES instance.
- **DescribeConcept:** Returns the SKOS descriptions from the associated thesauri by directly retrieving and handing over a SPARQL request with the given input keyword sent to the Virtuoso instance that stores the associated thesaurus knowledge.
- **SPARQL:** Similarly to **DescribeConcept**, this operation allows the user to run own SPARQL queries against the Virtuoso server's SPARQL endpoint.
- **GetSuggestions:** If the user starts to type some keyword and the first few keystrokes are sent to the LusTRE-ES, this operation will offer potential keyword completions.
- **GetRelatives:** Retrieves all concepts related to the input concept through a broader, related or narrower relation, if specified by the cross-walking parameter, also taking into account inter-thesaurus links.
- **GetSynonyms:** Finds all synonymous keywords for a given concept. If specified by the cross-walking parameter, also taking into account exactMatch inter-thesaurus links between different KOSs.
- **GetTopmostConcepts:** Lists the topmost concepts for a given thesaurus.
- **ResolveThesaurus:** For a given concept, finds the thesaurus it is contained in.

Service Example in Detail.

As an example for the LusTRE-ES functionalities and its usage, consider the **GetSuggestions** operation. The **GetSuggestions** operation is used to find concepts which have a label starting with the provided keyword (i.e. a sequence of characters typed in by the user). Case is ignored. As labels currently skos:prefLabel⁷ and skos:altLabel⁸ are considered. When specific languages are given as input parameter, LusTRE-ES considers only labels of the given languages. Similarly, only requested thesauri or service modules are used. By default, *all* available languages, thesauri and service modules are used.

⁷ <http://www.w3.org/2004/02/skos/core#prefLabel>

⁸ <http://www.w3.org/2004/02/skos/core#altLabel>

The **GetSuggestions** operation supports the following parameters:

Parameter	Type	Mandatory	Description
keyword	String	required	Keyword as search criteria, start of label
maxCount	Integer	optional	Maximum number of results
thesauri	String	optional	Comma-separated list of thesaurus-URIs
service	String	optional	Comma-separated list of serviceIds as given by GetCapabilities
languages	String	optional	Comma-separated list of languages based on ISO-639-1
cross-walking	Boolean	optional	Default is false, see below
source	Boolean	optional	Default is false, when true result contains thesaurus source

The **GetSuggestions** operation can be enhanced by specifying the **cross-walking** parameter. With **cross-walking=false**, this generally leads to a smaller but more focused result set. With **cross-walking=true**, LusTRE-ES will take into account the concept URI and consider all concepts linked by `skos:exactMatch`⁹ as the same concept.

Service Implementation.

The LusTRE-ES implementation code is organized in three separate components, the REST endpoints, the ServiceManager and the ServiceModules. Entry point for any call is the LusTRE-ES REST endpoint. It decodes the HTTP request and creates a suitable query for the ServiceManager. The ServiceManager delegates the query to all suitable ServiceModules. The modules return executable units of work that will retrieve the query responses from the SPARQL endpoint of LusTRE. These units of work are executed by the ServiceManager. After merging the results of the different executions, the ServiceManager returns the results to the REST endpoint. After creating the proper JSON response it is sent with the HTTP response. This architecture separates the REST endpoints from the Service Modules which contain the actual logic on how to answer the incoming requests. Furthermore it enables the possibility to retrieve results from different modules.

V. LUSTRE WEB INTERFACE AND EXPLORATION TOOL

In the last year, the LusTRE explorative Web GUI (LusTRE-WEBE) has been completely re-implemented in order to be more efficient and more user-friendly (see

<http://linkeddata.ge.imati.cnr.it/>). The user interface is divided in different sections, including:

- The *home tab* in which you find a short description of LusTRE.
- The *vocabularies tab* in which you can find all the information about which thesauri are included in LusTRE, the vocabulary versions, licenses and provenance.
- The *service tab*, providing the concise technical documentation required by third parties that want to integrate and exploit the LusTRE-ES services in their clients.
- The *indicators tab* which provides useful information, such as access statistics, linguistic coverage, etc.
- The *reference tab* in which you find information about publications pertaining to LusTRE.
- The *exploration tool* to search and browse the knowledge infrastructure of LusTRE.

The *exploration tool* has been implemented to make accessible to the user the knowledge infrastructure in LusTRE for browsing and searching for concepts in the available vocabularies. Its functionalities are:

- (i) To perform content negotiation compliant to Linked Open Data requirements and W3C best practices.
- (ii) To perform human readable browsing of the LusTRE content.
- (iii) To offer smart services to aid the users to better exploit the LusTRE content – such as “translation” by cross-walking between vocabularies.

A user can access to the LusTRE content via the exploration Tab which provides different entry points:

1. Browsing the Knowledge Infrastructure by clicking on the list of vocabularies included in LusTRE (Search&Browse concept window).
2. Search for a concept by starting typing a keyword (Search&Browse concept window).
3. Translation of a concept available in LusTRE (Translation window).

The Search&Browse activity can be useful when searching the keywords for annotating data. The user can search for a keyword, indicating a language and indicating whether she is interested in searching into the whole inter-linked framework or only in a specific vocabulary. The tool returns all the concepts matching the keyword and the respective vocabulary source. Then a search-refinement activity may be further performed by selecting one of these concepts. By clicking on a concept, the user gets all the information related to it:

- The concept’s description page. The concept page includes useful and detailed information about the concepts, e.g., the concept URI which can be used by linked-data applications to get the machine-interpretable serialization of the concept.
- The lexical information of the concept such as the definition, translations and synonyms.
- The semantic relation with other concepts such as: Broader, narrower and related concepts. They can be exploited to make coarser or finer the keywords to be

⁹ <http://www.w3.org/2004/02/skos/core#exactMatch>

exploited (i) in search and annotation tasks carried out in a client application which might not be yet integrated with the LusTRE-ES, or (ii) to discover related concepts which might be useful to find out, or (iii) by a user who wants to discover more about concepts and terminologies pertaining to specific domains.

For example, a user could decide to expand his conceptual search by exploring the broader term learning what it means and discovering that it is somehow related to other concepts which might be of interest, too.

LusTRE translation

LusTRE as a framework of inter-linked vocabularies, can not only be exploited stand-alone, but also jointly with others. We provide two practices for the vocabularies:

- The stand-alone use of a vocabulary which is basically the usual practice, similar to what is provided by the web sites of vocabularies such as GEMET and Agrovoc. The LusTRE contribution when considering the stand-alone use of a vocabulary is basically the publication as linked data of vocabularies which were not yet published in the LOD, such as THIST and EARTH.
- The joint exploitation of vocabularies within LusTRE which relies on the notion of cross-walking. The cross-walking is when LusTRE is taking advantage of inter-linking among vocabularies in order to enrich the set of information associated to concepts in one vocabulary.

Cross-walking brings an advantage in the translation as concepts which are not available in one language could be imported from other inter-linked vocabularies. For example: Let us suppose the user is interested in translating the word “soil” by the specific vocabulary EARTH which provides only Italian and English translations. First, the tool provides the set of concepts matching with “soil”, and the user selects the concept to be translated. Without cross-walking the tool provides synonyms available in EARTH which are only in English and Italian. Let’s repeat the search exploiting LusTRE as framework by checking the cross-walking functionality which returns not only translations and synonyms in EARTH, but also all those in EARTH’s inter-linked vocabularies. Then, the tool returns much more translations than before.

VI. INTEGRATION

In order to demonstrate and test the LusTRE usefulness and usability from the end-user perspective, the LusTRE exploitation services have been exemplarily integrated into two end user tools:

- The EUOSME metadata editor has been extended by LusTRE exploitation services to include novel features such as automated keyword completion, semantic search on keyword concepts and synonyms, or multi-language support (<http://showcase.eenvplus.eu/client/editor.htm>).
- The developer version of the JRC INSPIRE Geoportal has been prototypically extended by LusTRE exploitation services, e.g., to enable semantic search.

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VII. SUMMARY

In the last year, the work on LusTRE and the LusTRE exploitation services (LusTRE-ES) have made considerable progress. The content has been extended and was deeper interwoven with the Linked Open Data cloud. The LusTRE-ES implementation has been consolidated and tested and was extended by two parameters, the most important of which is the cross-walking parameter which allows inclusion of cross-vocabulary links in all operations. LusTRE has been given a more user-friendly and more functional GUI (LusTRE-WEBE) and is being extended by a visualization component (LusTRE-WEBEVis; not discussed in this paper; not yet fully implemented). The integration of LusTRE-ES with the EUOSME metadata editor and with the experimental INSPIRE Geoportal (developer version) allows for deep and broad experimentation and validation of LusTRE and TFES in the last project year by the pilot users. The technical interoperability has already been proven, but real end-user feedback about usability and perceived usefulness is still missing.

In general, we consider LOD principles and technologies a very promising approach to build federated thesaurus infrastructures, leaving the development and maintenance of thesauri in a decentral manner with their originators, but leverage the individual thesauri’s value by their connection and inter-linkage. In total, such an approach may globally save resources and locally increase value. However, how important the problems addressed really are for practitioners, must be shown by practice. Regarding the middleware design and base technologies used in and developed for the LusTRE implementation, we see easy ways for future extensions and take-up. In particular, we are considering the use of such an approach for flexibly adding powerful thesaurus functionalities to our commercial metadata framework Disy Preludio [4].¹⁰

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¹⁰ <http://www.disy.net/produkte/preludio.html>

Model based leakage isolation in water distribution system: a neural classifier approach

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Abstract—The paper presents an approach to detect and isolate leakages in water distribution networks. The first step of the methodology is the definition of the most sensitive nodes of the water distribution network that could be chosen as the places of pressure measurement points. Next, the numerical calculations of the hydraulic model for the purpose of determining the pressure variations for the standard, and during a leakage, operation of the water network were performed. At last neural classifiers were estimated so as to isolate the place of a leakage.

I. INTRODUCTION

Water losses in the distribution network is an important issue for the water companies. It should be reduced consistently and methodically. The amount of water losses can be assessed, in some waterworks with an old infrastructure, as 30% of the total water production [1]. It has a significant, negative impact on waterworks operation. Quick detection, localization and removal of leaks can reduce an environmental damages and costs of water losses.

In the case of normal operation of the network there is a typical pressure distribution on the nodes. A failure is an unusual situation that effects in the unusual variation in the nodal pressures. The decision support system is detecting faults in two ways [2]: by comparing the actual demands with declared ones (from a database, for points where monitoring devices are installed), and by comparing the actual demands with values calculated by a mathematical model.

Sometimes, water is stolen from a network. This means that the production of water exceeds its documented consumption. In the case of lack of a monitoring system, it can only be concluded that such a situation occurred with the use of modelling the water demand [3], [4]. Conversely, if there is a precise monitoring system and a precise hydraulic model, a comparison of recorded (or modeled) demands and water flows can be made. In such a situation it is possible to locate the places where significant disparities between consumption and production are visible.

II. PROBLEM FORMULATION

Leakage detection and isolation is commonly based on the measurement data analysis. The problem of monitoring points location itself was, however not solved in terms of local and international jural acts and norms. Furthermore, in the current

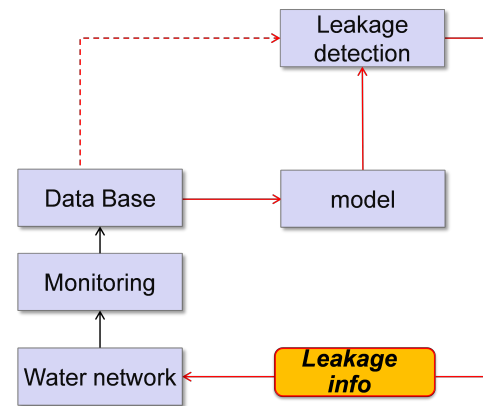


Fig. 1. A general methodology of leakage detection and isolation.

Polish legal requirements, there is no specific guidance on the sensitivity of detected leakages. Many papers, considering leakage detection in water distribution system have been published. Scientific journals are dealing with the approaches that could help to avoid the network faults (leakages) and to minimize the water losses when they have been already arisen i.e. [5], [6], [7], [8]. In general, techniques based on locating leaks by pressure monitoring devices are more effective and less costly than search in situ [9], [10]. Hence the purpose of this paper is to look at the leakage detection problem from two perspectives: diagnostic methodology and artificial neural network approach. The concept is to present a methods, that are possible to be implemented in practice.

III. LEAKAGE DETECTION

A. Applied methodology

The applied methodology used to detect leaks is based on the classic theory of diagnosis based on a model, and implemented in the supply networks to damage detection [9], [10], [11] with a hydraulic model [12], [13], [14], [15], [7], [16]. Diagnosis based on the model can be divided into two subtasks: detecting and isolation of a fault [5]. Detection of a fault is to observe the state of the object, and the location of a fault is to identify the damaged component of the system [17], [18], [5]. Observation of the object is based on the

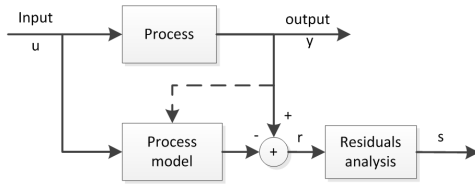


Fig. 2. Fault detection scheme

determination of residuals $\mathbf{r}(k)$ determined from the measured input signal $\mathbf{u}(k)$ and output $\mathbf{y}(k)$ using the sensors installed in the monitoring system, using the following, generic, formula [18]:

$$\mathbf{r}(k) = \Psi(\mathbf{y}(k), \mathbf{u}(k)) \quad (1)$$

where Ψ is a function of generating residuals, which depends on the type of the chosen strategy (the parity equation [18] or the observer [17]). At any moment of time k residuals are compared with the threshold value (zero in the ideal case or close to zero in real applications). The threshold value is determined using statistical methods and methods based on fuzzy logic [5], taking into account the presence of both measurement and model inaccuracies. If the value of the residuum is larger than the threshold, occurrence of a fault is concluded. Otherwise, it is considered that the system is working properly.

In the case of water distribution system the inputs \mathbf{u} are water demands (water consumption) at each node of the network. The outputs \mathbf{y} are the pressures at each node of the system. In the diagnostics of complex technological installations, methods of designing faults - symptoms relation that utilize expert knowledge play the most important role. Deep knowledge about the process operation helps to define this relation in a relatively simple way. Additionally, the diagnostic system designer can utilize the knowledge of process engineers or operators. The binary diagnostic matrix [5] is most often used. An example of such a matrix is presented in Table I. The symptoms s_i are pressures anomalies and faults f_j are leakages at the pipes j .

TABLE I
AN EXAMPLE OF THE BINARY DIAGNOSTIC MATRIX.

S/F	f_1	f_2	f_3	f_4	f_5	f_6
s_1	1	0	1	0	0	1
s_2	0	1	0	1	1	0
s_3	0	0	1	0	1	0
s_4	0	1	0	0	1	1
s_5	0	0	0	1	1	0
s_6	0	0	1	1	0	1

The matrix element in the j -th row and the i -th column has the value $v_j(f_k) = 1$ if the diagnostic signal s_j detects fault f_k and the value $v_j(f_k) = 0$ otherwise. In other words, the occurrence of fault f_k brings the occurrence of the diagnostic signal $s_j = 1$, which is called a symptom. The relation R^{FS} described by the binary diagnostic matrix can be defined by

attributing to each diagnostic signal the subset of faults $F(s_j)$ that are detectable by this signal:

$$F(s_j) \equiv F(s_j = 1) = f_k \in F : v_j(f_k) = 1 \quad (2)$$

It can be also defined by attributing to each fault $f_k \in F$ the subset of diagnostic signals $S(f_k)$ that detect the particular fault f_k :

$$S(f_k) = s_j \in S : v_j(f_k) = 1 \quad (3)$$

where, $S(f_k)$ determines the set of k -th fault symptoms. Each matrix row corresponds to the rule of the following type:

$$if(s_1 = 0) \wedge \dots \wedge (s_j = 1) \wedge \dots \wedge (s_J = 1) \text{ then } f_k \quad (4)$$

If the signatures are identical then the faults are indistinguishable. This type of situation commonly appears in the case of detecting the leakages in the water distribution network. The main factor that leads to this "inaccuracy" is the limited number of installed sensors. If every node in the network would be equipped with a pressure sensor then application of the above described methodology would allow to detect a leakage at every pipe. However, in fact only a small number of nodes are equipped with pressure monitoring device, so leakages at the level of individual pipes are indistinguishable, because many leakages are described with the same symptoms. Hence, the algorithm can indicate the group of pipes, which is shown at the Fig 3. In this paper, a passive method in the



Fig. 3. The indicated group of pipes which the same symptoms.

time domain to detect leakage is presented. Calculation of the residuals allows to determine the set of observed leakage signatures $s = [s_1, s_2, \dots, s_n]$, where each symptom s_i is defined as follows:

$$s_i = \begin{cases} 0 & \text{if } |r_i(k)| \leq \tau_i(k) \\ 1 & \text{if } |r_i(k)| > \tau_i(k) \end{cases} \quad (5)$$

where τ_i is a threshold related to residuum $r_i(k)$ generated by i th sensor, which is based on each sensor sensitivity to the leak. The details of construction the sensitivity matrix was described in [19].

The theoretical signature diagnostic matrix, used for fault location can be determined using a sensitivity analysis for the leak. The analysis allows to determine the impact of leakage

on the pressure in each node. If this process is repeated for each node and possible leakage it is possible to determine the sensitivity matrix [20] as follows:

$$S = \begin{matrix} s_1 \\ \vdots \\ s_n \end{matrix} \begin{pmatrix} f_1 & \cdots & f_n \\ \frac{\partial p_1}{\partial f_1} & \cdots & \frac{\partial p_1}{\partial f_n} \\ \vdots & \ddots & \vdots \\ \frac{\partial p_n}{\partial f_1} & \cdots & \frac{\partial p_n}{\partial f_n} \end{pmatrix} \quad (6)$$

where each element s_i is a measure of the leak f_j on a pressure drop at node p_i . It is very difficult to determine the value of the S analytically in the case of a real network because the water supply system mathematical description may includes a non-linear and non differentiable functions. For this reason the described method of determining the sensitivity matrix is based on a simulation. It runs as follows: the input is the same leak at each node, the output is the measured value of pressure drop at each node. Sensitivity matrix depends on the operating point of the system, ie. demands and boundary conditions.

Some sensors are much more susceptible to leakage than others. It is therefore necessary to perform normalization of sensitivity in order to allow comparison of results for different network nodes water. Each row corresponding to the sensor have to be divided by the maximum value occurring in a row, which is equivalent to a node that is most susceptible to leakage. This procedure leads to the designation of the sensitivity matrix of the following form :

$$\bar{S} = \begin{matrix} s_1 \\ \vdots \\ s_n \end{matrix} \begin{pmatrix} f_1 & \cdots & f_n \\ \frac{s_{11}}{\sigma_1} & \cdots & \frac{s_{1n}}{\sigma_1} \\ \vdots & \ddots & \vdots \\ \frac{s_{n1}}{\sigma_n} & \cdots & \frac{s_{nn}}{\sigma_n} \end{pmatrix} \quad (7)$$

where $\sigma_i = \max \{s_{i1}, \dots, s_{in}\}$, $i = 1, n$.

In order to identify the strongest relationship between leaks and pressure drop, the described procedure is based on the ε method developed by [21]. In this procedure, it is absolutely necessary to select a suitable threshold, which controls whether, or not, the leak has effect on the pressure data. The procedure is as follows: for the leaks that have less impact than the established threshold a binary value '0' is set. Otherwise, the value is taken as '1'. In this way, the sensitivity matrix is binarized according to the thresholds.

Normalization allows to use a unique threshold for all sensors, but the correct choice of the threshold is the most important element in the entire procedure. For the low value of threshold all binary matrix values are equal to 1 and can leakages can be detected only (It is possible to say if the leakage occurs). With the increase of the threshold values in the matrix appears more zeros. In the event that the threshold value reaches 1, only on the diagonal of the matrix values are equal to 1, hence, in this case the fault location is ideal, however, the sensor in each node of the network is required.

It can therefore be concluded that the location of measurement is the key factor that can extend an ability to detect network failures (leakages). Therefore, the location

of monitoring points should be designed so as to maximize the efficiency of the method used for network fault location [22]. Hence, the main objective of the algorithm of sensors deployment is to find a placement that allows to maximize the number of leakage signatures distinguishable faults. This means to minimize number of sections described by the same value of residuals $r(k)$.

The simplest way of determining the best sensor deployment is to use an exhaustive search method. This method is simple to implement, but requires checking all the existing combinations of subsets of sensors positions to determine the subset giving the largest value of the signatures. Using this method a global solution can be obtained, but it is only effective for a set of data with a small number of network nodes. Even a slight increase in the number of possible monitoring points makes exhaustive search becomes very inefficient [23]. Therefore, in the selection of measurement points location a multi objective genetic algorithm was used.

B. Application of neural networks

In [6] an algorithm to detect and localize the water leaks in water nets by means of water networks has been presented and the conclusion was that the tools of artificial intelligence fit good to solve such the practical tasks. In the following the results of subsequent investigation on using the neuronal nets to detect the water net failures are shown. In this case the structure of the neuronal nets used as the failure classifiers is different and more complicated than before and also another type of neuronal nets is tested. Hence, the application of neural networks is, in fact a complementary method to the classical diagnostic system. The neural network is, in fact modelling the diagnostic classifier, which was presented in Fig. 4.

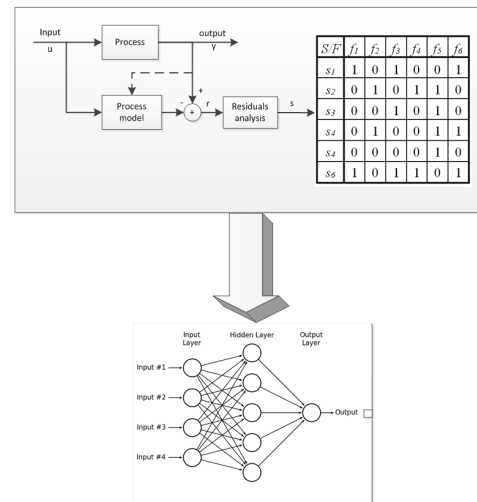


Fig. 4. Structure of the proposed system

The method based on sensitivity analysis, presented in paragraph III-A, has been used to estimate the suboptimal location of pressure sensors deployment. The selection of sensors placement was a task of choosing the most cost-effective sensors configuration satisfying certain criteria which

were possibly a small group of indistinguishable nodes, and the number of sensors. This task was realized with use of numerical simulations. The series of computations was performed so as to determine position of the individual sensors. In each of the numerical experiments a different number of installed sensors was assumed (from 2 up to 20 sensors). The idea of simulation of the water networks by means of neuronal nets and to use the neural models to conduct the fault diagnosis we have adopted from [6] and [5].

While modeling the hydraulic model with the MLP nets consisting of three layers they were parameterized by two parameters: number of neurons on the hidden layer changing from 5 to 30 and number of teaching runs (epochs) taking the values 200 or 500 or 1000.

While calculating the MLP nets the transition (activation) functions used for the neurons on the hidden layer are optionally hyperbolic tangent, linear, logistic and exponential and the functions used for the neuron on the output layer are hyperbolic tangent, linear or softmax function.

IV. RESULTS

The tests were performed on the example of water distribution system in Glubczyce. It is a town in the Opole province, Poland, in the district of Glubczyce situated on the river Psina. The town is inhabited with 23 778 people. The water supply network within Glubczyce provides water to 13 286 inhabitants (data from 2011). Water production in 2011 was estimated at 2.782 m³/day. In the city there is one pressure zone, in which pressure varies from $P_{min} = 0.2$ MPa to $P_{max} = 0.42$ MPa.

The calculations for the water net with 10 pressure monitoring sensors were conducted. In this case the water leaks have been simulated in 37 network nodes. Because of that the number of output neurons in the MLP nets equals to 38 (37 neurons for the water leak nodes and 1 neuron for the standard operation of the water network).

The classifier models have been created in form of the MLP neural networks with one hidden layer which are the most popular and most often used in the practice. By the learning experiments two parameters have been optionally changed: the number of neurons on the hidden layer from 5 up to 25 and the number of the learning runs (epochs) that took the values 200, 500 and 1000. The inputs of the neuronal net investigated are the water flow values in 36 or 44 nodes of the water net obtaining form the hydraulic model and the net output is the number of the SCADA measurement point that was the most sensitive against a simulated water leak. By all learning runs the teaching file consisted of 70% of all examples used and the testing and validation files amounted to 15% of the examples. In the calculation with 10 measurement points the number of all examples used was 304 and in the case of 20 measurement points the examples number amounted to 360. The examples data for learning the neuronal nets have been received due to the failure simulations done with the water net hydraulic model.

TABLE II
THE NEURAL NETWORK ESTIMATED FOR 10 MEASUREMENT POINTS;
LEARNING QUALITIES IN %.

No.	Neural network structure	Teaching quality	Testing quality	Validation quality
1	MLP 36-8-11	88,32	95,56	88,89
2	MLP 36-15-11	97,66	97,78	95,56
3	MLP 36-22-11	94,39	97,78	93,33
4	MLP 36-19-11	94,86	95,56	93,33
5	MLP 36-19-11	97,66	97,78	95,56
6	MLP 36-21-11	94,39	97,78	93,33
7	MLP 36-24-11	97,2	97,78	97,78
8	MLP 36-23-11	97,66	97,78	95,56
9	MLP 36-24-11	97,66	97,78	95,56
10	MLP 36-24-11	97,66	97,78	95,56

Activation functions used for the neurons on the hidden layer are optionally hyperbolic tangent, linear, logistic and exponential. The functions used for the neuron in the output layer are hyperbolic tangent, linear or softmax. The error functions (stop criteria) used at the teaching process are optionally the sum of squares function (SOS) and the entropy. Iterative BFGS (Broyden-Fletcher-Goldfarb-Shanno) algorithm was used to perform the optimization computing. It is a strong algorithm of second order with a fast convergence to get the optimal solution.

TABLE III
THE NEURAL NETWORKS CALCULATED FOR 10 MEASUREMENT POINTS;
TYPES OF ALGORITHMS AND STOP AND TRANSITION FUNCTIONS USED

No.	Learning algorithm	Error function	Hidden layer function	Output layer function
1	BFGS 25	Entropy	Logistic	Softmax
2	BFGS 22	Entropy	Linear	Softmax
3	BFGS 33	Entropy	Tanh	Softmax
4	BFGS 33	Entropy	Exponential	Softmax
5	BFGS 15	Entropy	Linear	Softmax
6	BFGS 52	SOS	Logistic	Tanh
7	BFGS 44	Entropy	Tanh	Softmax
8	BFGS 19	Entropy	Linear	Softmax
9	BFGS 64	SOS	Exponential	Linear
10	BFGS 36	SOS	Exponential	Linear

The calculation results obtained show that in the experiments with 10 measurement points the neuronal nets with the best ability to recognize and localize the water leaks in the water net are:

- MLP 36-15-11 with the cross entropy function as the error function, with the linear transition function on the hidden layer and with the Softmax function on the output layer;
- MLP 36-24-11 with the cross entropy function as the error function, with the Tanh transition function on the hidden layer and with the Softmax function on the output layer;
- MLP 36-23-11 with the cross entropy function as the error function, with the linear transition function on the hidden layer and with the Softmax function on the output layer.

V. CONCLUSION

Application of artificial intelligence methods to support the isolation of the leakages in the water distribution system introduces a new opportunities in the considered field. In fact, the performed calculations shown that neural classifier can reduce a number of nodes with the same symptoms of leakage. That means that the quality of isolation is improved in terms of accuracy. Secondly, the quality of classification of the leakage place is improved in terms of leakage quantity. The results presented in this paper indicates that it was possible to detect a smaller amount of water leakage than with use of "classical" diagnostic model.

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Study on the freshwater boundary of the Pleistocene aquifer in the coastal zone of Nam Dinh province

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Abstract: Saltwater intrusion has occurred in coastal aquifers in Nam Dinh province, Vietnam, which causes many negative effects on economic activities and especially residential life. Determining fresh-saltwater distribution is therefore necessary for authorities to have fundement to release policies and solutions timely to prevent this issue. Based on samples analyzing data, 3 regression equations of each couple of the conductivity, total dissolved solids (TDS) and chloride concentration were formulated and displayed on graphs, these can be applied to calculate TDS from available conductivity or chloride concentration values in any areas. Calculating all input data, a variogram was created, which indicates the spatial correlation between sampling points. Then, Kriging interpolation was applied in map-making process. Finally the spatial distribution of fresh and saltwater was delineated. Freshwater districts are located in the southern part of the Nam Dinh province and a small area in the north.

Keywords: saltwater intrusion; Nam Dinh; Pleistocene aquifer

I. INTRODUCTION

Available water resources, including surface water and groundwater, play an important role in the growth of population as well as economy in Vietnam. In fact, the negative effects of climate change, untreated sewage water and industrial waste water on surface water have made it more and more vulnerable with the decreasing quality leads to the possibility that groundwater will become the major resource for the future water supply of Vietnam. However, during the last decades, the uncontrolled utilization and increasing exploitation of the finite groundwater resources in Vietnam have resulted into several negative effects, especially in coastal areas. One of the major concerns encountered in coastal aquifer is the induced flow of saltwater into freshwater aquifer caused by groundwater over-pumping, known as saltwater intrusion. (IGPVN, 2011).

Nam Dinh is an agricultural dominated province located at the southern of the Red River Delta (RRD) in the north of Vietnam. It has a 72-kilometers long coastline bordering BacBo gulf (Gulf of Tokin). Latest statistical data published

by General statistics office of Vietnam state a total population of 1,833,500 (2011) persons and a population density of 1110 persons per km, ranked seventh in the whole country. Following this large population is the increasing demand for freshwater used for drinking and living. However, like many other coastal regions, the groundwater resources here also represent the negative effects of saltwater intrusion as mentioned above. According to National technical regulation on drinking water quality (QCVN 01:2009/BYT), acceptance limit for TDS is 1g/l while chloride standard for coastal zone is 0.3 g/l.

In Nam Dinh province, surface water is still used in northern and eastern areas, while in the south and the west, deeper groundwater resources has been increasingly exploited for domestic as well as economical utilization. According to report of IGPVN (2011), average water consumption per person is $\sim 0.2 \text{ m}^3$ per day and a total groundwater extraction for domestic purpose has been calculated to be more than $180,000 \text{ m}^3$ per day. Figure 1 indicates the portion of groundwater used for communal water supply in Nam Dinh province with the salinity boundary in Pleistocene aquifer.

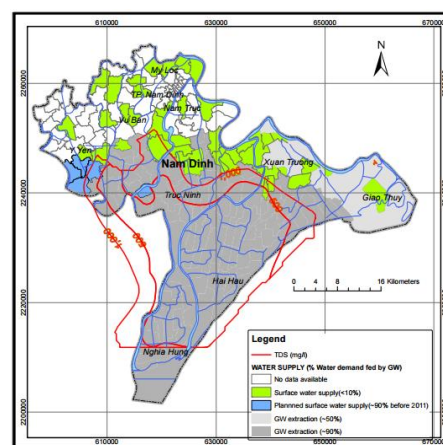


Figure 1. Portion of groundwater used for communal water supply in Nam Dinh province (IGPVN, 2011)

According to the Hydrogeological mapping of Nam Dinh (Nguyen Van Do, 1996) the Cenozoic formations in the RRD can be distinguished into 5 hydrogeological units, namely Upper Holocene (qh₂), Lower Holocene (qh₁), Upper Pleistocene (qp₂), Lower and Middle Pleistocene (qp₁) and Neogene (Pliocene, n). The research focuses on fresh-saltwater distribution in Pleistocene aquifer, which has a large potential deposit of freshwater, about 300,000m³ per day (Nguyen Van Dan et al, 2009). If that intrusion is controlled and prevented efficiently, water in Pleistocene aquifer can be exploited and used in a long term.

II. MATERIALS AND METHODS

A. Water samples

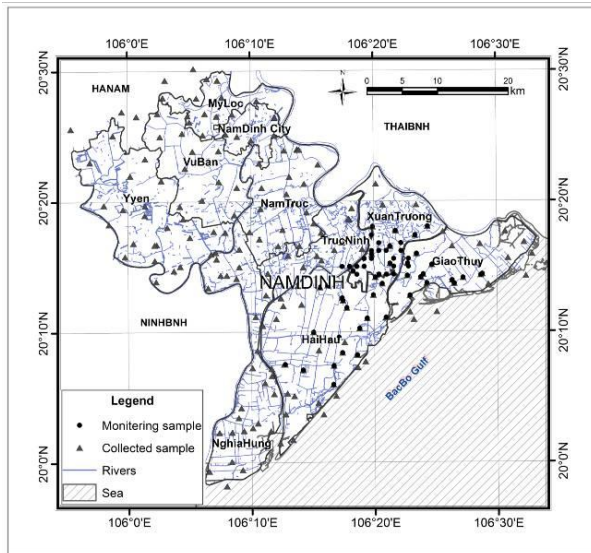


Figure 2. Location of study area and sample points

This study used 284 water samples in Pleistocene aquifer in research and mapping, where:

204 samples in all districts (triangle symbol in map) were collected from previous projects¹. Those samples were analyzed by chemical or geophysical methods.

80 samples (circle symbol) were taken in July 2014² around the freshwater boundary of previous studies. The results of measurement and analysis were used to particularize and standardize the fresh-saltwater boundary of study area.

B. Chemical analysis

Chemical analysis had been conducted in laboratory for investigating the total dissolved solids (TDS), conductivity and chloride concentration. Hence, the regression equations between them were formulated.

TDS was measured by 2 chemical methods. The first one is evaporating water sample and weighing the remains after

drying until the weight was unchanged at the temperature of $180 \pm 2^\circ\text{C}$. Hence, the formula:

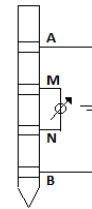
$$\text{TDS (g/l)} = (A-B)/V$$

where: A is mass of measuring cup + sample (g); B is mass of measuring cup (g); V is analyzed sample volume (l).

The second one is measuring the conductivity, using a Wenner microelectrode system. This system contains 2 sending electrode AB outside and 2 potential measuring electrode MN inside so that $AM=MN=NB$. The whole electrode system was dipped into sample water. Then, conductivity of water was defined by:

$$\sigma_w = 1/(K\Delta U/I)$$

where: K is Wenner electrode coefficient; ΔU is Voltage between M and N; I is electric current through AB.



With this method, TDS was calculated by the formula:

$$\text{TDS} = A \sigma_w$$

where: A is experimental constant; σ_w is conductivity of water.

C. Geostatistic

Geostatistics is a class of statistics used to analyze and predict the values associated with spatial or spatiotemporal phenomena.

The calculation of geostatistic is based on the sample data and on a variogram which characterizes the spatial continuity or roughness of a data set.

Variogram analysis consists of the experimental variogram calculated from the data and the variogram model fitted to the data. The mathematical definition of the variogram is:

$$\gamma(h) = \frac{1}{2} E[Z_{(x)} - Z_{(x+h)}]^2$$

Where: $Z_{(x)}$, $Z_{(x+h)}$ are the values of the variable of interest at 2 locations separated by a distance h. $E[]$ is the statistical expectation operator.

Furthermore, let $N(h)$ equal the number of studied pairs, the experimental variogram by:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z_{(x_i)} - Z_{(x_i+h)}]^2$$

The variogram model is chosen from a set of mathematical functions that describe spatial relationships. The appropriate model is chosen by matching the shape of the curve of the experimental variogram to the shape of the curve of the mathematical function (Spherical, Exponential, Gaussian, Power...)

¹ Nguyen Van Do, Doan Van Canh, BGI, IPGVN

² Trinh Hoai Thu, VAST06.06/14-15

Characteristic of variogram includes:

- Sill: value at which the variogram levels off.
- Range: The lag distance at which the variogram reaches the sill value.
- Nugget: In theory the variogram value at the origin should be zero. If it is significantly different from zero for lags very close to zero, then this variogram value is referred to as the nugget. The nugget represents variability at distances smaller than the typical sample spacing, including measurement error.

Geostatistical methods are optimal when data are normally distributed and stationary (mean and variance do not vary significantly in space). Significant deviations from normality and stationary can cause problems, so it is always best to begin by looking at a histogram or similar plot to check for normality and a posting of the data values in space to check for significant trends.

D. Kriging interpolation

The study used Kriging – a geostatistical analysis tool to interpolate TDS values from sample points.

Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. The general formula is formed as a weighted sum of the data:

$$\hat{Z}(s_0) = \sum_{i=1}^N \lambda_i Z(s_i)$$

where:

$Z(s_i)$ is the measured value at the i^{th} location

λ_i = an unknown weight for the measured value at the i^{th} location

s_0 = the prediction location

N = the number of measured values

Multistep process of Kriging includes: exploratory statistical analysis of the data, variogram modeling, creating the surface, and exploring a variance surface.

III. RESULTS.

A. The relationship between TDS, conductivity and Cl-

The relationship between TDS, conductivity and Chloride in couple is indicated by regression lines with equations attracted.

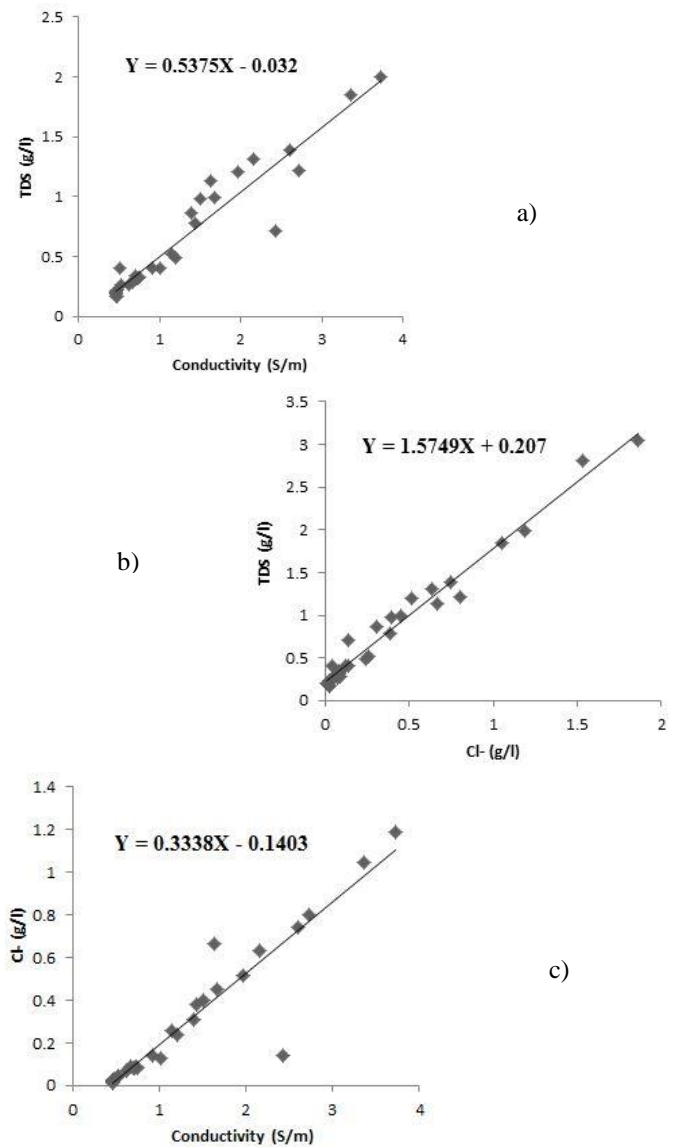


Figure 3. The relationship between:

- TDS and conductivity; $R^2=0.92$; $SD=15\%$
- TDS and Cl^- ; $R^2=0.98$; $SD=11\%$
- Cl^- and Conductivity; $R^2=0.88$; $SD=11\%$

The three equations have the form of a linear regression with standard deviation (SD) is not over 15%. By those, if a value among TDS, Cl^- and conductivity is available, the others can be calculated without measurements.

B. Primary fresh-saltwater distribution map.

This section presents the fresh-saltwater distribution with the 1 g/l TDS boundary which was interpolated from water samples of previous studies.

Among 204 water samples, 3 ones that seemed to be abnormal were discarded in process of removing gross error with a 95% confidence interval.

Creating a histogram of TDS value, there was an abnormal distribution with the peak skewed to the left, mean and

variance vary significantly. Therefore, it would be better to transform TDS data to logarithmic form with the nearly normal distribution (Figure 4) and the less significant deviation form stationary (mean = -0.221138; variance = 0.331773).

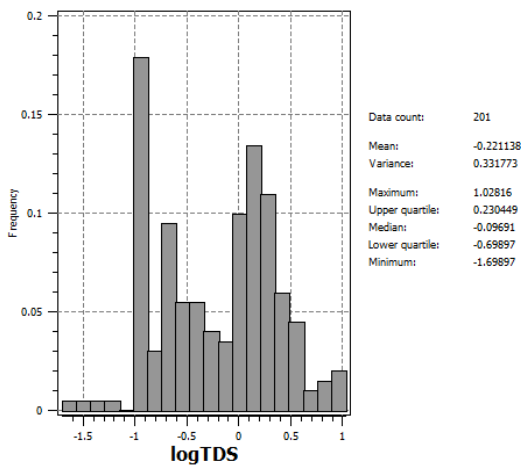


Figure 4. Histogram of LogTDS

Subsequently, the variogram of logarithm TDS was created with the direction of North East – South West, in which there are an major active fault (Van Ly) and some other faults (Nam Dinh, Yen Mo – Thai Thuy, Nghia Hung – Kien Xuong). Tested with azimuth from 40 to 50 degrees, the 45 degree situation gave the best result (Figure 5).

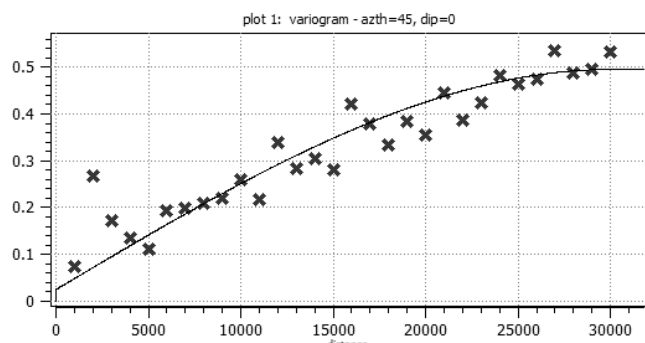


Figure 5. Variogram of logTDS.

Sill = 0.47; Range = 30000; Nugget = 0.025

The chosen variogram model is Spherical model, which exhibits linear behavior at the origin, appropriate for representing properties with a higher level of short-range variability.

Using the variogram modeled above, a map of LogTDS was created by Ordinary Kriging interpolation. Then, using Math tool to calculate the TDS. The TDS distribution was mapped with the fresh-saltwater boundary in Figure 6.

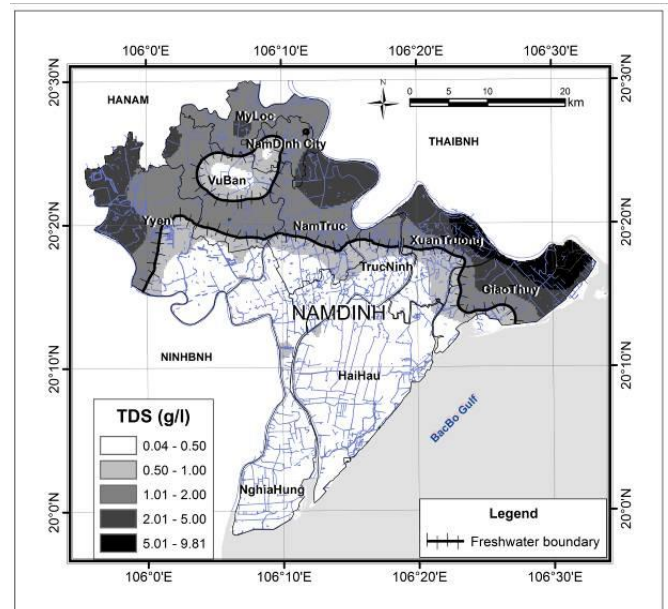


Figure 6. Primary fresh-saltwater distribution map.

C. Particularized fresh-saltwater distribution map

80 samples taken in July 2014 were added to combine with 201 samples above to particularize and standardize the primary map. To realize this task, mapping went through a similar process with the one above. The result is performed in Figure 7.

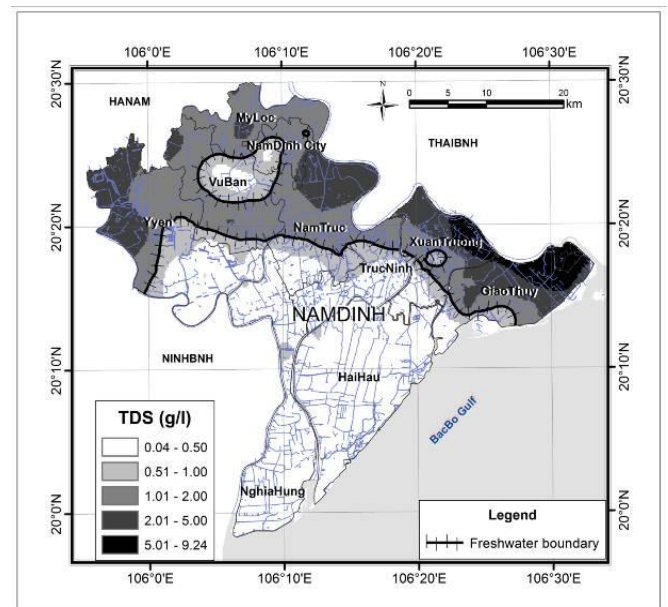


Figure 7. Spatial distribution of TDS of the Pleistocene aquifer in Nam Dinh Province.

According to the interpolation result, The TDS ranges from 0.04 to 9.24 g/l. The Eastern part of Nam Dinh Province, located in Giao Thuy and a part of Xuan Truong district, has the highest TDS content. Despite of bordering the sea, southern part of Nam Dinh Province has not got saltwater intrusion. This area is about 772.60 km², including the whole

Nghia Hung and Hai Hau districts, southern Y Yen, Nam Truc, Truc Ninh, Xuan Truong districts and a small part of Giao Thuy district. This can be temporarily explained by the available of remote water supply following tectonic fault, Karst zones of ancient stone pushed the saltwater far away to create quite great freshwater area. There is also a small fresh water area located in Vu Ban district and Nam Dinh city, covering about 58.73 km².

Put the two map created in comparison; there is a noticeable difference in the TDS distribution as well as fresh-saltwater boundary in Xuan Truong, Giao Thuy location, where is also the area gathering 80 new samples. Figure 8 zooms to this area and clarifies this difference.

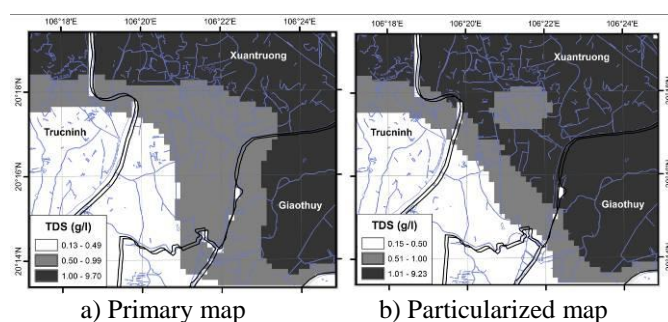


Figure 8. Difference between 2 maps

In the two maps, the white area (TDS < 0.5 g/l) and the light grey area (0.5 – 0.99 g/l TDS) represent water could be used for drinking and living. This freshwater area in primary map is continuous while that in the particularized is splitted and smaller. The total area of freshwater in Nam Dinh province in primary map is 859.76 km² while that in the second map is 831.33 km².

Attracted with interpolation map is the variance of prediction that was presented in Figure 9.

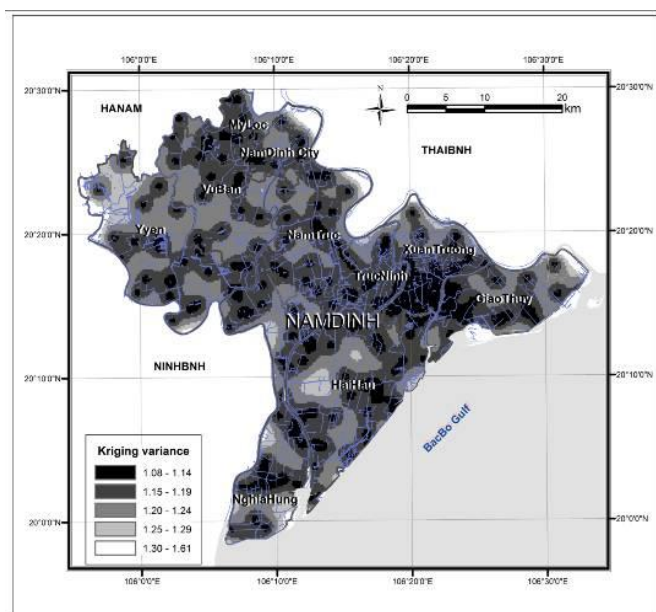


Figure 9. Variance of prediction map

It is obvious that at the locations having high density of sample points, variance value is lower, which also means the accuracy is higher. This variance of prediction map therefore could be used to evaluate the reliability of interpolation result.

D. Chloride concentration distribution map.

This map was created by calculating each cell of TDS distribution map (Figure 7), using the regression equation of TDS and Cl⁻ (Figure 3b).

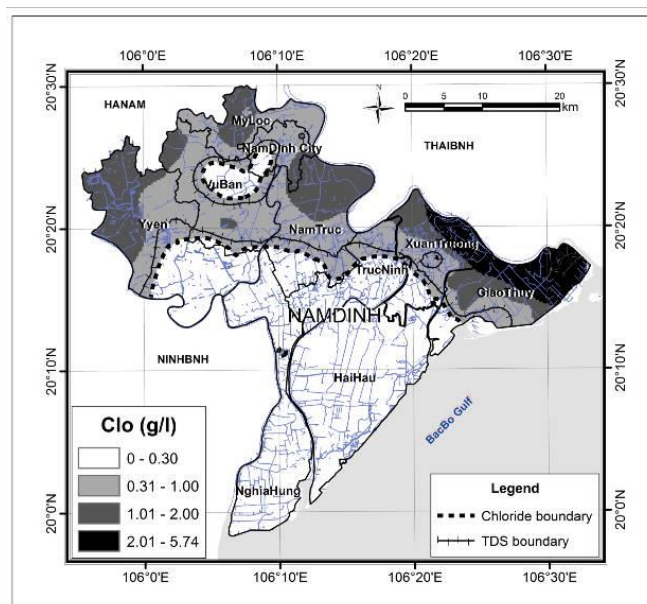


Figure 10. Chloride concentration distribution map

The 1g/l TDS boundary is also displayed in the map in order to compare with chloride boundary (0.3g/l, according to National technical regulation on drinking water quality for coastal zone). Then, it is obvious to see the areas meeting drinking water standard for TDS but not for chloride concentration.

IV. CONCLUSION

The TDS map with standard boundary of the Pleistocene aquifer was mapped, then particularized and standardized at Xuan Truong area. The TDS value ranges from 0.04 to 9.24 g/l. It defines the Pleistocene aquifer in Nam Dinh province containing 831.33 km² of freshwater with the great part located in the South and a small area in the center of the North. The investigating also delineated the vulnerable zones with high TDS content. Furthermore, the relationship between TDS, conductivity and chloride concentration formulated can be useful for studies and predicting models of Pleistocene in Nam Dinh province. The map of chloride distribution is created from the relationship formulated.

In fact, the accuracy of mapping depends on the distribution of sample points, the qualification of sample analysis and especially the interpolation, including which interpolation method was chosen and how it was applied. In

this study, the accuracy was not really high, which could be realized from the incompletely normal distribution in histogram, in spite of transformation of TDS value into logarithm. However, the mapping result could provide authority and environmental managers with a general view of fresh-saltwater distribution in order to have efficient exploiting and using water polices.

Data of previous projects, especially in last century, may be obsolete, which is a crucial handicap for researching about the recent quality. Therefore, it would be better continuously conducting new investigations and get up-to-date data in order to update information about the groundwater extraction status as well as achieve high accuracy in studies, calculations and create highly reliable maps.

ACKNOWLEDGEMENTS

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Sustainable Asset Lifecycle Management (SALM)

How SAP is managing IT assets by embedding sustainability aspects into entire business processes

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Abstract - SAP has set the target of bringing its carbon emissions down to 2000 levels by 2020. In line with SAP's corporate sustainability commitment, in close collaboration with other departments within SAP (global procurement, global facility management, controlling, sustainability, etc.), SAP IT set up a long-term project to optimize the entire lifecycle process of the company's IT assets while making it highly sustainable and lean. The Sustainable Asset Lifecycle Management (SALM)@SAP project comprises a number of separate projects and departments within SAP. The SALM@SAP project began in 2009 and both the overall project and its individual projects have continuously evolved since then. The purpose of SALM@SAP was to establish a process that was as lean and sustainable as possible – from asset purchase to disposal. Today, SALM@SAP has transformed from a project stage to a process that will be continuously improved.

collaboration, and IT asset management were significantly improved by embedding sustainability aspects. [8]

SAP uses a high number of IT devices (87,500 company owned laptops/PCs worldwide; for example, in 2014, SAP bought 6,000 devices for new employees, or to replace old or defective devices). In the last few years, the lifecycle of IT devices is generally becoming shorter, and the number of devices per employee has increased due to fast development and the pervasiveness of mobile devices. This naturally leads to an increase of global power consumption and associated CO₂ emissions as well as electronic waste. We want to counteract this trend. Against this background, SAP IT started to transform the complete IT asset lifecycle management by embedding sustainability aspects wherever possible into the process. [3, 7, 9]

II. GOALS AND BENEFITS

The aim of SALM@SAP was to integrate existing services, which had evolved from green IT projects, and to create a continuous, highly scalable, lean, and sustainable end-to-end process. All existing IT processes and related services have been examined and optimized, from purchase to disposal, in close collaboration with other involved departments.

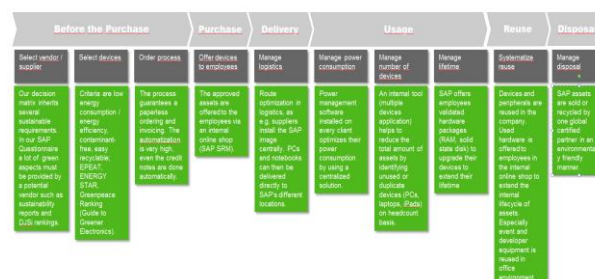
The SALM@SAP project no longer focuses only on single projects but the sustainability of an asset along its entire lifecycle. It helps create a greater awareness for sustainable topics for all of the employees involved in the processes as well as uncover synergies to apply and ideas to share.

I. INTRODUCTION

SAP's vision is to help the world run better and improve people's lives. Our mission is to help every customer becoming a best-run business. We do this by delivering technology innovations that we believe address the challenges of today and tomorrow without disrupting customer business operations. Innovation and sustainability are core to our business – from our solutions to our operations to our social investments. [1] The responsible use of IT at SAP is an integral part of reaching that goal.

The SAP IT Services, Client Technology & Field IT department is responsible for all topics related to the internal IT workplace of all SAP employees worldwide and is the driving force behind green IT projects within SAP IT. Projects for power management for IT equipment, printing at SAP, virtual

Sustainable Asset Lifecycle Management
Overview



III. PROCESS DESCRIPTION

A. Selection of Suppliers/Working with Suppliers

SAP is working to make social and environmental criteria mandatory in the selection process for new suppliers. To help support sourcing practices, a section on sustainability has been added to our global master contracts, asserting the right to receive information from our suppliers on labor standards (freely chosen employment, child labor avoidance, working hours, humane treatment, nondiscrimination, etc.), health, safety, environmental protection, and other key sustainability issues.

In addition, our suppliers are required to accept the SAP Supplier Code of Conduct. [6] This code is based on international standards that are relevant to our industry, including the Electronic Industry Citizenship Coalition (EICC) and the United Nations Global Compact. It contains provisions regarding human and labor rights, corruption and bribery, and waste, water, air, and materials.

In regular meetings with our external partners and producers, we search for further optimization of the supply chain from an environmental perspective.

B. Selection of IT Assets

Device selection at SAP follows strict criteria regarding the environmental impact. Only devices from selected suppliers committed to the SAP Supplier Code of Conduct [6] (see A.) will be taken into consideration during the selection process. In addition to the energy efficiency of the devices, maintainability and reparability are important points. In particular, EPEAT and ENERGY STAR certifications, as well as Greenpeace ranking [5], are considered.

Other selection criteria comprise state-of-the-art technical standard; global availability; compatibility and quality requirements of IT and lines of business (LoBs), for example, weight and mobility aspects are important criteria for a sales representative; for a developer, its overall computer performance is more important; price and overall lifetime; and security and ergonomic requirements.

To drive progress throughout our supply chain, SAP has made sustainability an integral part of the global procurement policy that all procurement employees must follow. The goal is to make sustainable procurement a seamless part of the procurement organization, thereby supporting SAP's overall sustainability goals. This integration involves a continual evaluation of trade-offs between economic, environmental, and social aspects of our sourcing decisions. [4]

After the final selection of a new standard device, prices are negotiated by SAP's global procurement organization and the order is initiated from our external service providers through the SAP Supplier Relationship Management (SAP SRM) application. SAP SRM is a technically and functionally sophisticated software application for electronic procurement and management of supplier relationships. The checkout process in SAP SRM guarantees a completely electronic and

paperless ordering and settlement of bills. The automation rate is very high, even credits are calculated automatically.

The demand will be calculated on a regular basis with our suppliers by taking various criteria into account, such as the lifespan and the number of employees to achieve an optimal delivery time.

C. Ordering Process

SAP employees purchase assets via a highly scalable, automated, and paperless ordering process in our online purchasing portal (available through SAP SRM). The hardware catalog of suppliers is updated automatically on a daily basis (including the availability and delivery times).

Employees initiate the order of the right device for their work following a recommendation from SAP IT. They can choose between different standard models depending on their requirements (for example, sales representative might prefer a smaller/mobile device). In some locations (such as at our headquarters in Walldorf, Germany, or at Newtown Square, Pennsylvania, USA), we make devices available at an on-site Mobile Solutions Center for employees to test and try out standard devices and read our recommendations). To support the selection process, recommended devices are flagged in an internal online catalog provided by software from our acquired company Ariba. Since 2014, SAP IT has marked the most sustainable products with a green leaf. This green leaf informs our internal customers about a product's sustainability on the one hand, and creates awareness for green thinking on the other. We want to encourage our employees to think about sustainability before ordering.

As an alternative to ordering a new device, we check whether a reused device is available. Reused devices are of high quality and fulfill all criteria for up-to-date working devices (for example, SAP reuses devices before purchasing new equipment). If no reused device is available, the order is forwarded to a supplier. In addition, employees can choose whether they want a reused device or peripheral (for example, mouse, keyboard, or mobile phone). For more information, see "F. Reuse and Disposal."

We do not want to force our employees to order reused hardware at SAP. Our aim is to convince them to think more sustainably and consider all of the choices available. In the end, we hope they make the most sustainable choice. Our experience shows that our approach is working.

D. Delivery Process

The delivery and shipment of IT assets and related peripherals is prepared and executed by external partners. This includes the entire imaging process.

An SAP image is installed by our suppliers so the PCs and notebooks can be delivered directly to SAP locations. Transport routes have been optimized to reduce CO₂ consumption. Fixed service-level agreements (SLAs) have been defined to optimize delivery time. SAP works together with suppliers to further optimize logistics and packaging, for

example, through transportation in flight boxes or bulk packaging to reduce packaging material.

One further optimization of the delivery process in terms of sustainability is the use of lightweight pallets. These pallets are lighter than the euro pallets normally used and have a potential saving of 160 kg of CO₂ per pallet.

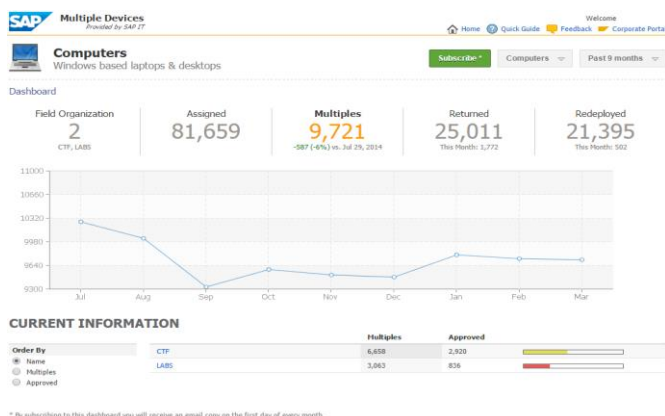
E. Usage of IT Assets

The user of a device can help ensure it is used in an environmentally friendly manner. To assist our employees, SAP has implemented several tools to measure to save as much energy as possible.

The power consumption of laptops is optimized by optimized power settings and power management software installed on all SAP-imaged PCs and notebooks.



Another approach is to reduce the total amount of assets per user. Therefore, an internal asset management tool helps SAP IT identifying unused and duplicate devices. A management approval process for additional devices is required to help limit the number of multiple devices.



Through a master thesis project, we are currently working on a technical solution to expand the monitoring of energy consumption that includes all workplace-related IT assets, such as PCs, notebooks, monitors, headsets, and so on, per user on a global level to identify potential ways to save energy. Mobile devices such as tablets and mobile phones will be included as well in this more accurate definition of power consumption of our workplace.

At the moment, we are also developing a dashboard that allows users to screen their own sustainability-related consumption, for example, power consumption in their workplace, to create even more awareness.

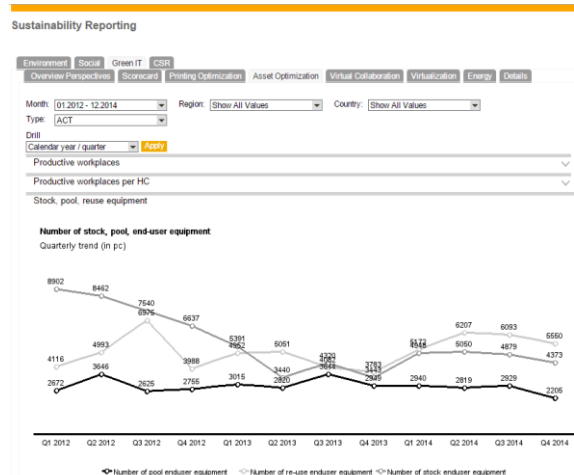
We are considering a future project that looks at the cradle-to-grave lifecycle assessment of SAP IT; in other words, evaluating the overall CO₂ equivalent emissions of an asset from production to disposal along its lifecycle process.

F. Reuse and Disposal

Returned devices and peripherals are reused within SAP. For example, laptops used at conferences for a very short period of time, are offered in our internal shop as “gently used” to employees ordering new hardware. As a result, in 2012, about 1,500 devices (laptops, PCs, and monitors) were reused – in Germany alone.

Smaller peripherals, such as mice and keyboards, are collected and, after being checked and cleaned, are reused as well.

With awareness campaigns such as internal “IT Recycling Days,” SAP motivates employees to return unused devices to the IT department and to reuse devices instead of ordering new ones.



Damaged or obsolete devices are handed over to certified suppliers and then sold or recycled in an environmentally friendly manner. Basically, we have a two-step process for recycling old devices at SAP.

First, we signed a contract in 2011 with a global distribution partner that is one of the leading sustainable disposal companies worldwide (global 100 most sustainable corporations list). Our partner acts strictly according to the regulations of the ISO 14001 norm. This norm specifies requirements for an environmental management system to enable an organization to develop and implement a policy and objectives that take into account legal requirements and other requirements to which the organization subscribes, and information about significant environmental aspects. In 2014, all SAP locations (excluding those from our latest acquisition, Concur) committed to adopt our global disposal process for used hardware. Second, selected local partners dispose of the outdated hardware. These partners must follow strict SAP recycling regulations. Since SAP works with such a small amount of distribution partners, with one chosen globally, we are able to manage and monitor the entire process closely.

IV. CHALLENGES

To establish the SALM@SAP project, one of our main success factors was to gain the interest and buy-in of all involved employees right from the beginning. We needed to convince the service leaders responsible for the individual projects of the necessity of cooperation, which required additional workload and meetings for those involved. These additional meetings and discussions were necessary to convince everyone of the critical nature of all sustainability-related topics within an asset lifecycle.

For example, SAP IT presented this topic in global Web sessions to demonstrate the success of the project and to obtain feedback from the employees (improvement suggestions, feature requests, and so on) to further improve. Sustainable asset lifecycle is part of an openSAP course called “Sustainability and Business Innovation – Sustainability in IT aka Green IT.” [10]

We encountered several challenges related to individual projects within the overall SALM@SAP project.

In a global project implementation, it is difficult to overcome the various accounting, tax and legal requirements in different countries. This is the case, for example, in the disposal of IT assets. While we found that a company that functions as a global enterprise can have policies and processes that apply to all subsidiaries worldwide, it sometimes makes more sense to work with a local company in the execution to ensure that all of the local requirements are taken into consideration. To that end, SAP has established strict recycling regulations globally to fulfill all of our requirements, including sustainable aspects.

Another challenge we found was related to the usage of the IT assets. As a global business application software provider, SAP is affected by the environment in which we function, an industry marked by continuous improvement and innovation. This was the case in terms of our use of centralized power management software. This software switched devices such as notebooks and desktops into remote after a certain time of non-use or after a set period of time.

Using power management software on PCs and notebooks allowed SAP to significantly decrease the amount of fossil fuels consumed and helped reduce our overall carbon footprint. Total client energy decreased from ~767.000 kilowatt hours (kWh) in January 2011 to ~376.000 kWh in December 2014 as a result of its implementation as well as the fact that newer computers consume much less power than in 2010. When SAP IT began implementing centralized power management, more than 70% of employees used a desktop PC. Today, more than 90% use notebooks or laptops – both of which consume less energy overall. As the service is neither as relevant nor beneficial as in the past, SAP decided in June 2015 to discontinue the power management service. We now offer an optimized power profile available in our internal software download center online for our employees.

Overall, we view SALM@SAP as a source of strength. We are able to better monitor and react much faster to changes, since we not only consider individual projects but also the entire lifecycle as a whole. Distributed data acquired during key steps in the asset lifecycle process is uploaded automatically into our sustainability performance management system. The data is reviewed quarterly and reported to key stakeholders within SAP.

Type:

Drill
Cal. year / quarter

Green IT Scorecard

	Quarter	Score	Status
▼ De-Materialization		92,7 %	
▶ Reduce amount of IT assets used		107,1 %	
▶ Foster use of virtual collaboration		67,1 %	
▼ e-Waste			
▶ Volume of server equipment disposed			
▶ Volume of EUS HW equipment disposed			
▼ Energy		107,3 %	
▶ Data center energy per FTE			
▶ Average power consumption per server			
▶ % virtual servers of all servers		101,7 %	
▶ % new virtual servers of all new servers		108,6 %	
▶ Average power consumption per end user client		111,7 %	

Despite some challenges, SALM@SAP is now a well-accepted, well introduced and well working process of the daily work environment at SAP.

G. Achievements and Best Practices

In 2014, 3.92 gigawatt (GWh) hours of client energy were saved compared to 2011 through the implementation of power management software, use of state-of-the-art technology, and reduction of assets.

SAP was recognized as a 2013 Computerworld Honors Laureate for our SALM@SAP project. This nomination

recognizes organizations that have used information technology to promote and advance public welfare, benefit society and business, and change the world for the better. [7]

Normally, sustainability is mostly seen as an additional requirement in projects. With the establishment of SALM@SAP, we have taken a step further. We want all of our business processes to take sustainability into consideration. The outcome of this project is a notable advancement and a best practice that can certainly be implemented at many other companies in a consulting project.

We believe that the entire SALM@SAP project can be adapted by other companies. All processes within the project, from asset purchase to disposal, can be used as examples for best practices. Paperless ordering, green flag indicators for purchasing, and continuous monitoring are just a few examples.

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Tailor-made Energy Consulting for Private Households

The approach of the Austrian R&D project “EnBe2.0”

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Abstract: Energy consulting for private households can make a significant contribution to achieving energy efficiency targets. The extent to which these targets can be validated, however, depends to a large degree on the consideration of the individual demands of the consulted people and/or households. Not only do socioeconomic, environmental and structural factors like income, climate or living space have an impact on the effectiveness of energy consulting but also the consideration of people’s habits, needs, preferences, values, attitudes etc. Due to the fact that the common practice of energy consulting is insufficient in terms of taking into account household and end-use energy consumer related factors, energy savings gained through energy consulting for private households have, as a result, been unsatisfactory. To achieve more energy savings with the help of energy consulting the R&D-project “EnBe2.0” was launched and has been carried out by an interdisciplinary consortium in Austria. The aim of the project EnBe2.0 is to develop an energy saving tool (EnBe2.0-Toolbox) that meets the multifaceted requirements of end-use energy consumers and assists energy consultants with target-group orientated energy consulting practices for private households. This paper gives an overview of the EnBe2.0 project and highlights the project’s bottom-up and participatory approach.

Keywords: *energy consulting; energy use; consulting tool; participatory research; energy related behavior, values, private household*

I. INTRODUCTION

Due to the new Austrian energy efficiency law, which is based on EU directives and was implemented in Austria in January 2015, improving energy use behavior of private households – for instance through energy consulting – has become an increasingly important topic on the Austrian policy agenda. Our analysis that we obtained from both practical observations and literature reviews shows that cultural background and socio-economic factors have an impact on household energy use and consumption. This also corresponds to the level of effectiveness that energy consulting has at the household level [1, 10, 19]. Furthermore, our research has lead us to pose further empirical questions: Which other factors influence the energy behavior of private households and to what extent? Which further factors have an impact? Also, how do we

measure these factors properly? How could we then frame energy consulting measures and recommendations in order to meet the various needs, preferences and expectations for both women and men? This paper provides an overview on various approaches that are stated in literature and outlines the approach of and methods used in the ongoing Austrian R&D-project “EnBe2.0 Tailor-made energy consulting for private households”. Furthermore we present preliminary results, especially concerning the concept, implementation and main elements of the EnBe2.0-Toolbox, a decision and communication support system for energy consultants.

II. BACKGROUND

A. Legal Framework

Looking at the current situation, one has to state that an unsatisfactory level of energy savings has been achieved at the private household level which might lead to a failure in achieving pre-defined energy efficiency targets. The Austrian energy efficiency law, which came into force on the 1st of January 2015, stipulated that power supply companies have to implement energy efficiency measures for end-use energy consumers, such as private households. About 40 percent of the energy savings have to be realized in private households throughout measures, such as connecting households to the district heat network, installation of smart meters or through energy consulting [7].

These circumstances lead to a major challenge for power supply companies and their energy consultants as well as for the other organizations providing energy consulting. Currently, energy advisors in Austria have the possibility to disseminate technical knowledge for energy consulting in the basic-training scheme A (A=AnfängerInnen, means beginners) and further training for scheme F (F=Fortgeschrittene, means advanced).

B. Common Practice in Energy Consulting

Within the existing trainings, neither household nor customer related factors are effectively integrated into trainings or consist of the core set of recommendations proposed within the framework of consultancy services. Aspects like current living conditions, individual preferences, behavioral patterns, perceptions of life and lifestyles, beliefs of comfort or coziness,

as well as other personal and social issues are usually underestimated. As a consequence, a set of rather unspecific, inadequate and un-personalized measures have only lead to missed opportunities for achieving potential energy savings.

For example, advice provided to replace common household items with more energy efficient devices could well be rejected by individuals on grounds that it does not fit in with their lifestyle expectations or social identity [14]. In this regard, social identity and lifestyle may be evident through consumption habits, e.g. by looking at (individual) car choice [21]. Individual habits and practices also play a major role for the acceptance and effectiveness of energy saving measures. Due to the lack of transparency surrounding energy use [14] and especially due to the fact that people do not consume energy directly but rather use services that consume energy such as heating, light, warm water, cooking, and internet etc. [24], has meant that daily routines in which energy consuming activities are carried out within households are relevant for the analysis and adoption of energy saving measures [16, 21].

III. FOCUSING ON PRIVATE HOUSEHOLDS

Studies concerning the energy behavior of residents from various countries show that cultural factors influence the energy performance and effectiveness of energy saving measures. For instance, Norwegian households in general prefer a high number of lamps in a room to create a cozy atmosphere whereas Japanese households tend to prefer one light bulb placed in the ceiling [23]. Furthermore, through our literature review, we highlight a number of cultural differences concerning the importance of feedback about energy consumption and especially concerning the manner on how feedback is presented [9]. Studies show that citizens in the UK and Sweden have a high interest to compare their current rate of energy consumption with their own previous consumption habits. However, citizens of both countries are less interested in comparing their current habits with those of other households [12, 17]. On the contrary, Japanese citizens are much more interested in comparing themselves with each other rather than with their own previous consumption habits [18]. Finnish citizens as well desire normative comparisons [11]. Another impressive finding was gained through the testing of four different designs of energy consumption by simply focusing on just two of the samples – one sample in the US and the other in Norway. The design that ranked highest in the US attained the least approval in Norway and was characterized as “childish”, “unclear” and “difficult to interpret” [4, 22].

In many cases, cultural background and socio-economic factors have shown to have an impact on energy use and consumption and, as a result, on the level of effectiveness provided by energy consultation. When investigating decision making processes between cohabitants or family members on energy consumption, personal factors have shown to not be the only relevant criteria [2]. For example, diverse individual ambitions and beliefs concerning quality of life, household management, comfort and so forth affect the willingness to accept energy saving measures among housemates to a considerable extent [19]. Therefore, tailor-made energy consulting measures can be more acceptable as well as more effective. Energy saving measures can only be achieved by

considering a broad set of possible social, behavioral, psychological, ethnic and financial influences on household residents.

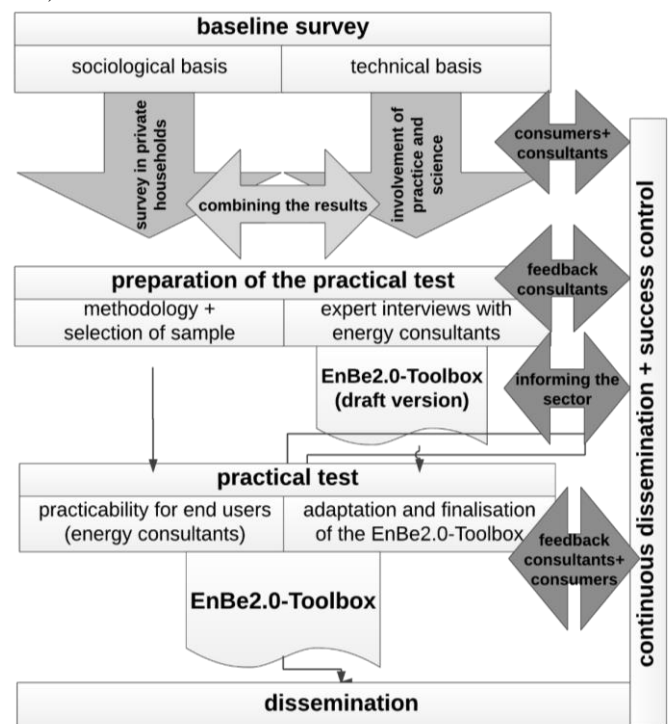
IV. THE AUSTRIAN R&D-PROJECT ENBe2.0*

Based on the hypothesis that the common practice of energy consulting in Austria is insufficient as far as taking into account household and individual factors and, hence, inadequate in terms of achieving energy saving at the private household level, the research and development project EnBe2.0 was launched by OFI Technologie & Innovation GmbH and Büro für nachhaltige Kompetenz (Consultancy for Sustainable Competence) B-NK GmbH. The interdisciplinary consortium, which combines gender expertise as well as socio-scientific and technical knowledge, has carried out this research. Through a bottom-up participation process of the both target groups, two set of beneficiaries were integrated into the research and development process: (1) end-use energy consumers in private households and (2) energy consultants. The project started in July 2014 and has a scheduled duration of 27 months.

A. The project's aims

The project's overall aim is to provide a user-friendly, gender- and diversity-sensitive consulting tool which assists energy consultants by customizing energy saving measures and recommendations to the individual characteristics and needs of end-use energy consumers, who for their part, would perceive these measures as being viable and effective for their own daily living patterns. The outcome of the project EnBe2.0 is the implementation of the research results into a practical toolbox (EnBe2.0-Toolbox). Overall, EnBe2.0 will provide a set of more effective measures that would gain higher acceptance among targeted consumers as well as among end-user consultants.

Fig.1: Scientific approach of the project EnBe2.0 (B-NK & OFI)



* The project is funded by the Austrian Research Promotion Agency (FFG) and the Federal Ministry of Transport, Innovation and Technology (BMVIT).

Further aims of the project “EnBe2.0 Tailor-made energy consulting for private households” are:

- To survey which social and individual factors influence the acceptance and effectiveness of energy saving measures for private households in Austria;
- To develop cluster samples of households, based on a survey data about current living conditions, values, individual preferences, etc.;
- To analyze and reflect the current practical work of energy consulting for private households in Austria;
- To conduct a critical review of the well-known energy saving measuring and practical recommendations;
- To provide a user-friendly, gender- and diversity-related, tailor-made consulting tool (EnBe2.0-Toolbox) for energy consultants.

V. BASELINE SURVEY

A. Theoretical Basics

In general, energy consumption is based on activities which are embedded in cultural, social, psychological and individual contexts [1]. The routines within the members of private households, in which energy consuming services are carried out, are highly relevant for the adoption of energy saving measures [16, 21]

Focusing on the acceptance and, hence, effectiveness of energy saving measures in private households, one main distinction can be made between the individual and the household perspective [2, 19]. Both dimensions are relevant – at least for households with more than one person – since some energy saving measures can be implemented individually (e.g. duration of showering) while others may require arrangements between the household members (e.g. reducing room temperature, duration of lightning etc.). As literature review shows, behavioral change in energy-related concerns is more often investigated at the individual level than at the household level [13, 15]. To investigate the impact of household-related factors, different approaches are stated in the literature [19]. Due to page limitations we will not go into detail in this paper, but rather, we want to summarize the relevant characteristics at the household level, as follows [1, 19]:

- A household can be understood as a system which aims to fulfill a specific set of functions; specifically the fulfillment of material and non-material needs in specific situations;
- A household can be understood as an organizational system with mainly gender-biased responsibilities and gender differentiated approaches to jointly used services;
- A household can be understood as a space as well as a platform for addressing all possible discussions, feedback and participatory decision making processes;
- A household can be described based on its members’ assumptions on the quality of life that could lead to

descriptions such as: “the home as a haven”, “the home as a place for activities” etc.;

- A household can be understood as a source of material and non-material items, such as household income or knowledge.

Focusing on energy-relevant factors from an individual perspective, personal aspects gain more importance. Due to the fact that different psychological, behavioral, sociological theories are used, different approaches have been developed to categorize energy-related individual factors and therefore create various levels of classification. In regards to the energy-related household factors, as described above, we will neither discuss energy-related individual factors in detail in this paper, but rather provide an overview on some important pertaining aspects [10, 14, 19, 20]:

- Socio-demographic factors, such as gender, age, income, education etc.;
- Perceptions on life in general and the (individual) assumption on the quality of life;
- Values, tastes, needs, preferences and attitudes;
- Habits, manners, approaches and behavior ;
- Knowledge, information, awareness, interests, possibilities of choice.

Furthermore, these personal or individual factors are also influenced by societal processes, located on a micro-level dimension (household members, family etc.), on a meso-level dimension (neighbors, peers etc.) as well as on a macro-level dimension (cultural, ethnical, societal aspects etc.).

A broad variety of energy-relevant aspects in private households has to be considered regarding energy consulting that meets the individual demands of end-use energy consumers. Our literature review shows that some aspects may influence groups of people differently [19]. Therefore, it is necessary to identify the influences and their coherences to create tailor-made energy consulting. With this approach, we assume some advantages: on one hand to deliver highly acceptable and therefore effective energy saving measures and, on the other hand, to not overwhelm nor overemphasize end-use energy consumers with already known or inappropriate measures.

B. Measuring individual and societal energy-relevant factors within the quantitative EnBe2.0-survey

To investigate and characterize different types of households and their approach towards energy issues in general and to energy saving measures in particular, a quantitative online based survey among private household has been carried out (n = 541).

Based on a literature review, the quantitative survey with an online questionnaire was developed in order to investigate and characterize different types of households and/or individuals and their approach towards energy issues in general and to energy saving measures in particular. The survey addresses end-use energy consumers in private households in Austria.

The questionnaire consists of two main parts:

The first part of the questionnaire focuses on appropriate energy saving measures and to what extent each measure is feasible to the respondent. Therefore seven different energy saving measures were selected, as shown in the following table:

TABLE 1: OVERVIEW AND CHARACTERISATION OF ENERGY SAVING MEASURES INQUIRED IN THE ONLINE QUESTIONNAIRE FOR THE ENBE2.0 PROJECT. ABBREVIATIONS SEE TABLE 2. (B-NK 2014)

Energy saving measures and their characteristics			
Energy saving measure	A	C	L
Replacement of light bulbs by LED lamps	E	€	-
Replacement of a refrigerator by a more efficient refrigerator	E	€€	-
Arrange rooms in a way that radiators can emit heat freely into the room	B	-	-
Apply flow-restrictors (or flow regulators) on water faucets or shower head	E	€	-
Avoid devices' standby mode by using specific switches	B	-	-
Use a matching lid when cooking	B	-	-
Replace windows by thermally insulated windows	E	€€€	§

Due to usability reasons regarding the time the user spends filling out the questionnaire, we could not inquire more on energy saving measures than those listed above. In order to enable a certain comparison with other energy saving measures, we developed a scheme to characterize different types of measures. For characterizing the energy-saving measures, the three following criterion-groups were developed of which at least one measure from each group was implemented into the questionnaire:

- (1) Energy saving approach [A];
- (2) Expenditures to realize the measure [C];
- (3) Legal permission [L].

As shown in Table 2, each of the three criteria has multiple characteristics. For the energy saving approach [A] we distinguish between measures which primarily require behavioral change (B) and measures that primarily deal with changes in equipment and infrastructure in general, such as the replacement of devices through more efficient devices (E). Concerning the expenditures for realizing the measure [C] we distinguish between four levels of costs. The criterion legal permission [L] addresses the fact that some measures such as changes made to a building require obtaining permission. In most cases these measures are related to the fact whether one is possessing or renting one's own residential property. For example, a person renting a flat might replace standard windows with thermally insulated windows as an appropriate measure in terms of saving energy, but the person will not have control over the implementation of this measure.

TABLE 2: CRITERIA FOR THE CHARACTERISATION OF THE ENERGY SAVING MEASURES INQUIRED IN THE ENBE2.0 ONLINE QUESTIONNAIRE. (B-NK 2014)

Criteria for characterization of energy saving measures		
Criterion	Characteristics	Code
Energy saving approach [A]	Replacement of equipment, facilities, infrastructure	E
	Behavioral change	B
Expenditures [C]	No costs occur	-
	Low costs occur	€
	Medium costs occur	€€
	High costs occur	€€€
Legal Permission [L]	Unnecessary	-
	Necessary	§

The second part of the questionnaire deals with individual and social factors that – as literature has shown – do have an impact on energy consumption in private households. Therefore questions out of the following topics were developed and implemented in the online questionnaire.

- Attitudes towards energy, such as awareness on energy saving, being interested in energy consumption benchmarks, favoring renewable energy;
- Knowledge about energy, such as the ability to estimate the energy consumption of appliances, knowledge about the costs of energy units like cost for one kWh electricity;
- Consumer behavior and preferences, such as individual media usage, importance of design of products;
- Household demands and standards towards tidiness or coziness, perceptions towards the utilization of the household space;
- Values, lifestyle and beliefs towards quality of life, also such as ecological awareness, risk disposition;
- Sphere of life and importance of e.g. health, family, wealth;
- Socio-demographic items, such as gender, age, income, education.

The quantitative EnBe2.0-survey has been carried out with the online-tool "Lime Survey". The time-period to fill out the questionnaire started at the end of October 2014 and ended in the middle of March, 2015.

C. Analysing the data

We analyzed the data with the help of statistical methods like principal components analysis, factor analysis and linear regression. Based on the statistical analysis, we developed five types of end-use energy consumers. Each of the five types is

characterized with the help of statistically significant combinations of elements out of the survey categories, such as sphere of life, values, household demands, consumer behavior, and knowledge about energy as well as attitudes toward energy. For instance, one of the types is characterized as follows: education, knowledge, independence, autonomy, gainful employment and independence are important spheres of life. People of this type tend to be considerate, generous, environmentally and health-conscious, interested in technology and new media; they want their household primarily to be practical and clear as well as an area where people stay and to receive guests; concerning consumption environmental labels and energy efficiency classes are considered; implementing energy-saving measures is rather seen as troublesome.

Although the correlations are statistically significant, it is clear that the descriptions for each type are only tendencies and that overlaps occur. Nonetheless the five types can be differentiated well. In the En.Be2.0-Toolbox the types serve as a basis for target-group oriented communication of energy saving measures. Therefore, we compiled five sets of terms, concepts and arguments (one set for each type), which provide potential connecting points for target-group oriented communication and the presentation of energy saving measures. The five sets are compiled out of the statistical analysis as well as of the results from the qualitative research.

D. Qualitative research with the help of face-to-face in-depth interviews

Additionally to the quantitative survey, a qualitative survey was conducted (n=14), to gain in-depth information on energy-relevant factors on the households' and their members' level. In particular the lead questions focused for instance:

- Responsibilities about household sectors such as monitoring energy consumption and processing energy bills;
- Needs, habits, practices towards household activities (regarding energy consumption);
- Energy saving approaches (save money, normative values);
- Dependencies between the individual and the household level regarding energy consumption patterns, if several residents are living together;
- Dependencies between the individual and the societal level regarding energy consumption patterns.

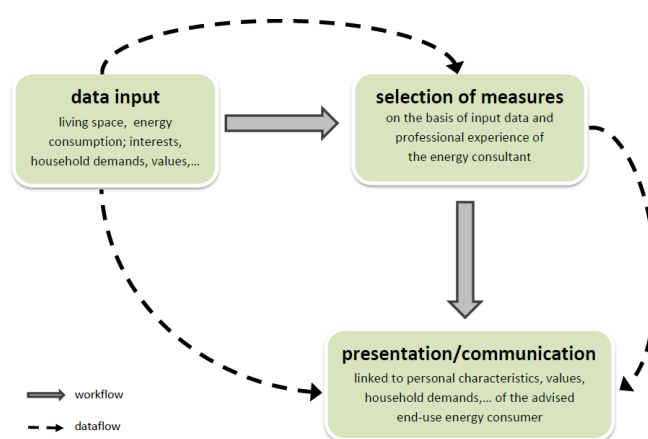
The results of the qualitative survey enriched the outcomes of the statistical analysis of the quantitative data from the online survey. Especially concerning enhanced and widened connecting points for target-group oriented communication of energy saving measures.

VI. FIRST DRAFT OF THE EN.BE2.0-TOOLBOX

The En.Be2.0 toolbox is a decision and communication support system for energy consultants who advice end-use energy consumers in private households.

The toolbox consists of three main elements: 1) data input, 2) selection of measures and 3) presentation and communication of the measures. As shown in Fig. 2, the information recorded (data input) through the energy consultant has an effect both on the selection of measures and on the proposed connecting points for target-group oriented communication of the selected energy saving measures.

Fig.2: Main elements of the En.Be2.0-Toolbox (B-NK & OFI)



The first draft of the En.Be2.0-Toolbox was implemented with Microsoft Excel. The software provides adequate functionality for the algorithms used. In the first spreadsheet information concerning the household (e.g. living space, number of residents, heating system, power consumption) as well as information concerning the advised person (=end-use energy consumer) is gathered. Additionally to input fields for household data, we developed five questions which shall be asked by the energy consultant and which allow a quick characterization and classification of the advised person in terms of the five types from the statistical analysis. Due to the fact that reality differs from statistically significant ideal types, the advised person is not classified to only one type, but rather the five types are ranked in accordance to the importance for the description of the advised person. To compute a ranking order, the answer options from the questions in the data input sheet are assigned with different scores for each type. The type which ranks highest (in sum) is presented first to the energy consultant, then the second highest, and so on. The rank-score of each type is also presented, to show how distinct the ranking order is.

According to the input data also energy-saving measures are selected and get displayed as 'more suitable' for the advised person. For instance regarding technical equipment of the household, considered expenses for measures or concerning the competence to implement measures from a legal permissions' view (ownership, rent, community issues etc.). The energy consultant has the possibility to adapt the selection, e.g. when the selection differs compared to his/her professional experience or compared to his/her estimated suitability of certain measures. Actually more than 160 energy saving measures are included in the En.Be2.0-Toolbox. Furthermore, the energy consultant has

the possibility to add other measures and adapt already included measures.

Both the selected measures and the connecting points for target-group oriented communication are displayed to the energy consultant simultaneously, in a second spreadsheet. This facilitates to communicate selected measures in a way that directly addresses the advised person and hence leads to higher actual energy savings.

VII. PRACTICAL TESTING

At the moment, the project team is working on the further development of the first draft of the En.Be2.0-Toolbox. Throughout the project cycle feedback from energy consultants has been implemented and the toolbox has been adapted accordingly. We have gained much positive feedback from energy consultants of various organizations for the first draft of the toolbox, as well as we detected concrete starting points to extend, adapt and further develop the tool. As a next step, the En.Be2.0-Toolbox will be proof-tested by energy consultants in real life energy consulting situations with end-use energy consumers. This will create the possibility for further feedback and ensure the user-friendliness and the usability of the toolbox. Therefore we collaborate with energy consultants from both, major power supply companies in Austria and NGOs. All these experiences will be monitored, reflected and processed for the ongoing development of the En.Be2.0-toolbox.

Based on an evaluation of the process, the final version of the toolbox will be developed. Finally, the EnBe2.0-Toolbox as a tailor-made energy consulting tool will be a result of a bottom-up process that will be achieved by integrating multiple feedback loops from various perspectives – stakeholders, energy consultants as well as end-use energy consumers.

VIII. OUTLOOK

At the conference in September 2015 we want to present the project EnBe2.0, its approach and the first preliminary results.

- Overview on the common energy consulting practice in Austria, its actors and their professional background
- Results based on the quantitative online survey as well as on the qualitative survey
- First Draft of the EnBe2.0 Toolbox
- Reflection on the up-to-date participatory approach

ABOUT THE AUTHORS

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The affordances and use of green citizen engagement web tools

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Abstract— *The purpose of this paper is to analyse if and how three different green citizen engagement web tools create the basis for different levels of environmental citizen participation. This is relevant in both an e-governance context and an environmental policy context, as it is normally assumed that ICT as such can be used to strengthen such participation, without looking neither at the special opportunity structure that the applications offer (their affordance) nor the actual use of the applications. Theoretically, the paper departs from Contextual New Medium Theory. This theory focuses on technological practices, and demonstrates how these are created in interplay between technology, policy ideas and actor skills. Empirically, the paper unfolds as a comparative case study of three different green citizen engagement web tools, chosen due to the differences in their affordance. It is then analyzed whether these differences result in differences in environmental participation. It is concluded that while differences in participation are indeed found, these differences seem to hinge at least as much on the activities of skilled actors such as involved civil servants, web- and game administrators than on the affordances of the web applications.*

Keywords—*green citizen engagement web tools, participation, affordances, contextual new medium theory, case study*

I. INTRODUCTION

Man-made climate change constitutes a ‘super wicked’ global problem [1] and in recent decades, international governmental bodies have acknowledged the scale and intensity of the problem of climate change. Yet the primary international climate change mitigation agreement – the United Nations Framework Convention on Climate Change (UNFCCC) with 195 member states as signatories – has not been able to mitigate climate change effectively. In fact, contrary to the commitment by the international climate change mitigation governance system to reduce greenhouse gas emissions, the exact opposite has occurred [2]. As a consequence, the international multilateral governance system based on individual states meeting their obligation has been described as failing [3] [4].

Since the top-down initiated approach to climate change mitigation is not functioning effectively it may be worth considering an approach that involves local governments and

citizens. There are empirical as well as theoretical arguments for pursuing this strategy. The proportion of energy consumption by individual citizens (including for domestic use and personal transport) accounts for approximately half of all energy being used, which provides an empirical argument for involving citizens individually or at the community level [5].

The theoretical argument for citizen involvement in relation to climate change mitigation can be found in various bodies of literature. Thus, the benefits of citizen participation in (environmental) policies have been dealt with both in the steering or management oriented governance literature, under such headings as co-production, collaborative innovation or co-creation [6] [7], and by the literature on democratic participation [8] [9]. However, it is important to notice that these two bodies of literature stress very different benefits of participation; the governance literature stressing the increased efficiency of public policies, and the democratic participation literature stressing the improvement of civic virtues and political capital [10].

Thus, a possible successful response to global climate change is to focus on individual citizen or local community behaviour and consumption patterns, which can be facilitated through internet- and communication technology (ICT). Green web applications are examples of such ICT solutions aimed at citizen driven climate change mitigation [11]. Green web applications are citizen engagement web tools that contain climate change information relevant to citizens interested in learning more about climate change mitigation in order to reduce their energy consumption.

The effects and functionality of such tools have been studied in connection with the enactment of local government climate change action plans. However, their affordances in connection with citizen participation have not yet been addressed [11]. There is a need to explore how citizen participation can be increased by employing low-cost scalable solutions such as green web applications under the slogan ‘think globally, act locally’ [10].

Research question: 'Do the affordances of green web applications enable different levels of citizen participation in environmentally sustainable practices?'

II. LITERATURE REVIEW

This literature review will address green web applications and citizen participation in climate change mitigation. The purpose of doing this is to demonstrate that while both green web applications as well as citizen participation in climate change mitigation has been studied on their own, we have found no literature, which combines the two. We are therefore describing a new field of research in this article, making our inquiry rather explorative.

Green web applications are a relative new phenomenon within climate change mitigation e-governance literature [11], and in one of the few studies on these applications it has been examined whether green web applications can strengthen individual engagement in climate change mitigation based on a qualitative study of six respondents using two applications (ClimateAwarenessⁱ, Mapmyclimate.dk). The study applied actor-network theory in combination with other concepts from 'science, technology & society studies theory'. The study found that applications can be conceived of as 'scaling instruments' (according to actor-network theory) that can move participants from powerlessness to being empowered by changing or redefining the scale of the climate change [12].

There is very little academic literature, which focuses explicitly on citizen participation in climate change mitigation. Some of the few examples are [13] and [14]. While Whitmarsh et al. is a rather broad collection of articles dealing with ways to engage and motivate citizens/the public to engage in climate change mitigation, and the difficulties and barriers in relation to such engagement, Hoff & Gausset is more narrowly focused on the ways in which citizens and public authorities collaborate in order to tackle the climate change challenge. For this reason they define citizens participation in climate change mitigation as '*The participation of citizens in any type of collaborative activities with public agencies to either formulate, decide on, and/or implement measures that have to do with climate change mitigation.*' [10:30]. The way these 'collaborative activities' are studied is through a series of 'exemplary' case studies covering (part of) the field of possible collaborative arrangements between local public agencies and citizens. Such interventions can be initiated either by government agents (which is what we see in the case studies below) or by citizens, but most often in a collaboration in which one of the two poles weighs more than the other. Interventions can target either individual change (which is what we see in the case of ClimateAwareness below) or collective changes (which is what we see in the cases of TheClimatePartyⁱⁱ and UrgentEvoke.com below). Since collective change requires the participation of a large number of individuals, and since individuals are influenced by collective behaviour, most interventions mix both aspects to various degrees.

One of the main results of this research is that in general the interventions targeting and involving collectives of different kinds (e.g. housing cooperatives, villages) are more successful than interventions targeting individuals, both in terms of producing bigger CO₂-reductions (even though this can be difficult to measure accurately), but also in terms of other tangible and less tangible benefits such as creating jobs and local revenue, increasing citizens learning about climate change, creating ownership to projects, empowering citizens, creating spaces for deliberation, strengthening the community, etc. [15].

III. METHODOLOGY

This study examines the relationship between the affordances of green web applications and their use by citizens who wish to mitigate climate change. It unfolds within a framework that aims at technologically mediated innovations in political practices, and is based on an analysis of three green web applications that are selected because it is hypothesised that they enable different levels of participation. Technology (*in casu* green web applications) in combination with skilled actors (e.g. households, citizens or game players) and political discourse (e.g. climate change mitigation policies) constitute environmentally friendly social practices. These three elements make out the social practice, where it is the material (the green web applications) that has an important role in securing coherence within the social practice. The study is carried out as a text analysis of the green web applications in the form that they have on-line supplemented by secondary analyses of the web sites.

IV. THEORY

This study is based on a comparative analysis of three greenweb applications. Green web applications are understood as technologically mediated innovations in political practices (TMIPPs). This concept was originally introduced to replace the term 'electronic democracy', which was understood as denoting the complex relationship between computer, technology, and political processes in order to avoid the technological determinism present within e-governance literature at the time [16].

A. The Contextual New Medium Theory

The study examines how the applications enable environmental sustainable citizen participation practices, which motivates using the Contextual New Medium Theory (Contextual NeMTⁱⁱⁱ) [17]. The Contextual NeMT is specifically developed for analysing social practices involving TMIPPs. The model contains three elements – political discourse, skilled actors, and technology. The model has two key points.

First, the reason for selecting the three elements in the first place is related to the understanding of practice-as-entities according to social practice theory. Practice-as-entities are the

outcomes that emerge from practice as they appear in real life and are comprised of three elements: discourse, skills, and artefacts [18]. It is the relationship between and among these elements that constitutes the character of a social practice. The elements of practice may be examined individually, but cannot be analysed independently because the elements are always circulating around and among each other thereby providing the argument for selecting the elements.

Second, according to the double sided arrows in Figure 1 the model can be read from left to right or from right to left. The arrows pointing towards left mean ‘is constitutive of’ or ‘creates the basis for’. This means that technology (e.g. ICT) is constitutive of skilled actors. Following this the skilled actors are constitutive of political discourse (e.g. policy). However, the model might also be read from left to right. In that case, the arrows should be read as ‘affects’ or ‘places demands on’, i.e., political discourse affects, or places demands on the related skilled actors, who can be administrators responsible for implementing the policy. In turn they would place demands on technology.

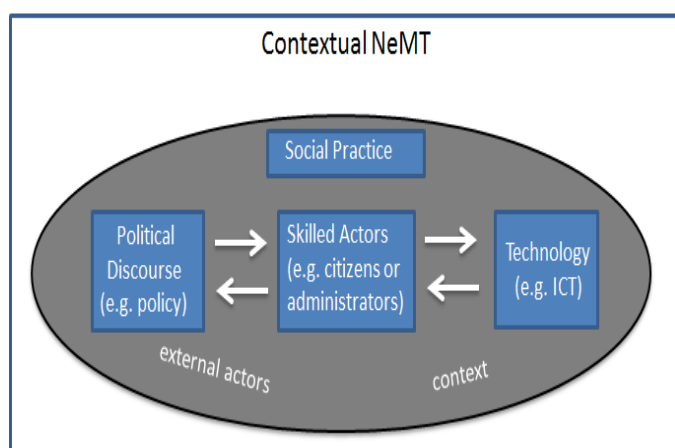


Figure 1: The Contextual NeMT

B. Citizen participation

While the academic literature on citizen participation in climate change mitigation activities is sparse, the literature on citizen participation in public policies in general has been booming in recent years. There are probably a number of reasons for this but a reason often cited is, that the solution of increasingly complex (‘wicked’ or even ‘super-wicked’) social problems demand a collaboration between public agencies and civil society. Public agencies do not have the resources nor the knowledge to solve a range of social problems, and are therefore ‘forced’ to seek the help of citizens/civil society/business in trying to establish well-considered solutions [19].

Seeing citizen participation in this perspective has led to the development of such terms as co-creation and co-production of public policies and services [7] and collaborative (public sector) innovation [6]. While these frameworks all pay considerable attention to the needs and wishes of citizens and other civil society actors, the

perspective is none the less a governance perspective, with the main aim of providing new and hopefully better public sector services or policies with the same or fewer resources. Citizen participation in collaborative arrangements can, however also be seen from a democratic perspective. In connection with environmental policies different authors have formulated what has been called ‘the pragmatic tradition’ within citizen participation theory [9] [20] [21]. This tradition has focused on how citizen participation contributes to the substance of the policy output through providing knowledge to policy development, and how it also reduces the uncertainty connected with scientific knowledge. Furthermore it has stressed how citizen participation can contribute to accept, confidence in and ownership to policies, but also how citizens can obstruct policy implementation if they feel excluded from the policy process.

A more normative theory also exists within citizen participation theory. This theory explicitly takes its point of departure in ideas about participatory democracy [8] [22]. The focus of writers within this tradition is on the development of the civic potential of the individual citizen through the process of participation, and thus also on citizen empowerment. Newer developments within this tradition put more emphasis on the potential of deliberation in developing the democratic capacities of citizens [23].

In considering the citizen participation dimension of the cases of green web applications presented below, it is well worth keeping these two views on citizen participation in mind. Thus, it is interesting to ask if and how these applications enhances the problem-solving capacity of the involved public agencies in terms of climate change mitigation, and if they can at the same time create citizen involvement in climate change mitigation, ownership to the process and be considered legitimate by citizens.

V. DATA

The study is based on three green web applications. A green web application is defined as ‘*interactive application software that governments can use to motivate climate change mitigation behaviour or to enable environmentally sustainable social practices. They are free of charge for the end-user and may not function in a commercial context*’ [11]. The analysed applications are *ClimateAwareness*, which is a web based energy reduction guide catalogue; *TheClimateParty*, which is a municipal web based climate change mitigation campaign; and *urgentevoke.com*, which is a social innovation network game.

VI. ANALYSIS

In the following the three green web applications will be analysed using the Contextual NeMT model. As should be clear from figure 1, this will entail dealing with three issues for each application: The technology on which they are based, the political discourse setting the course for their use, and the actors involved. The content of these elements and their

mutual relationship will be described, as well as the citizen participation practice that springs from their enactment.

A. ClimateAwareness

Technology

ClimateAwareness is a website that contains energy savings guides. It exists in two versions – one aimed at small and medium sized enterprises, and one aimed at private citizens. This analysis will focus on the version aimed at citizens.

ClimateAwareness aims at reducing user's energy consumption. It provides a catalogue of 'energy reduction guides' that individuals or families can use as recipes for energy reduction in different spheres of everyday life, such as lighting, transport, shopping and lifestyle habits. At the core of the application is an online catalogue which contains more than 200 'energy saving guides' that tell the user about behaviour changes that can reduce costs by implementing environmentally friendly changes. These guides are sorted into different categories, e.g. lighting, food and transport. Each category contains guides in more specific sub-categories. Thus, the category 'consumption and life style' has instructions on climate friendly restaurants, washing laundry at low temperatures and environmentally friendly cleaning products.

The application motivates energy reduction behaviour by providing information about the potential savings that could be achieved by making the necessary changes. The potential savings are estimates. The economic indicators are followed by instructions on how to achieve the savings. Secondly, the application contains a 'competition module' in which individuals or groups can compete against each other on who can implement the most energy reduction guides. These groups can consist of teams of families or neighbours, who can share the experiences, knowledge, and know-how they have gleaned from using the website.

Political discourse

The citizen-centered version of ClimateAwareness is developed in collaboration between the small software company IngenCO2 ('No CO2') and the municipalities of Skanderborg, Herning, Aalborg and the research project CIDEA at the University of Copenhagen. The reason for the municipalities to get involved in the construction of the website is, that it was considered an integral part of their work on mitigating climate change. Thus, all three municipalities are frontrunners in local climate mitigation efforts, and have elaborate climate change mitigation action plans. Their plans cover the municipality as a geographical area (compared to municipalities that only have a climate plan for the municipality's own units) [24]. This means that citizens as well as small and medium sized enterprises are seen as important players in the municipality's CO₂-reduction efforts, which is why they have a special interest in ClimateAwareness.

Skilled actors

According to the Contextual NeMT there may be two groups of relevant actors. The explanation for this has to do with the double sided asymmetrical double arrow between the actors on one hand and the political discourse and technology on the other as illustrated in Figure 2 below:

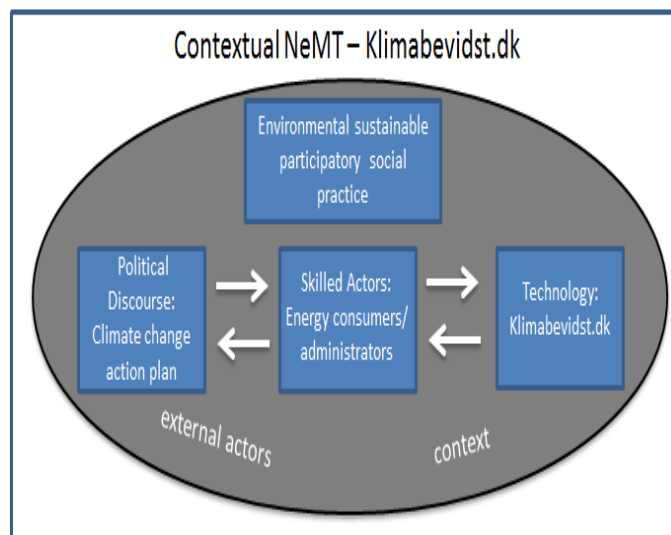


Figure 2: Contextual NeMT – ClimateAwareness

Reading the figure from left to right the political discourse place demands on skilled actors who can be municipal climate change administrators. These administrators choose to implement ClimateAwareness as part of a climate change plan in order to promote energy reductions among citizens (ibid.). Alternatively, the figure may be read from right to left beginning with the technology – *in casu* ClimateAwareness – which creates the basis for skilled actors who are energy consumers that use the green web application, which in turn creates the basis for realising targets in a municipal climate change action plan.

ClimateAwareness and citizen participation

ClimateAwareness enable citizen participation in climate change mitigation through their implementation of energy saving guides. Secondly, the 'climate battle' encourages participation at the community level. The size of the community can range from two families competing against each other up to larger communities e.g. two groups of multiple households or many groups with multiple households. Alternatively, a local or possible even a regional government can organise climate battles. As the manager of a climate battle the administrator can monitor progress and encourage action within the teams.

Even though the application's participation affordances enable households implementing energy reduction guides it does not offer any possibilities concerning environmental or democratic deliberative dialogue between citizens and government. The participation is a 'one way street' where the government can encourage citizens to change behaviour in order to meet policy goals. Because of that ClimateAwareness

is considered to have limited affordances for environmental citizen participation.

Danish municipalities can use ClimateAwareness free of charge, and the application has been implemented on Local Government Denmark's website. In general, the municipalities that use the application do not follow up on the use of the application by other measures e.g. contacting citizens or businesses that use the application in order to increase their engagement [11]. As a consequence there is no other citizen engagement in connection with the application other than users implementing the energy reductions guides [24].

ClimateAwareness enables a basic level of citizen participation. The application supports one-way communication from the municipality to citizens and businesses based on information databases that citizens can access through ClimateAwareness.

B. TheClimateParty

Below we will analyse TheClimateParty according to the same logic as in the analysis of ClimateAwareness:

Technology

TheClimateParty is a climate change mitigation information campaign that the municipality of Skanderborg in Denmark implemented in 2011-2012.^{iv} The campaign was based on citizen participation. The starting point for the campaign was to avoid lecturing the public and turn energy reduction into a task that can be entertaining as well as challenging to work with. Citizens were considered key agents as up to half of all energy consumption occurs in the private home thereby legally speaking being out of municipal reach. The information campaign *'aimed to turn the energy reduction task into to a mutual challenge for every citizen and business and not a problem, which can be solved by exclusively placing the responsibility on the municipal administration.'*^v

The campaign consists of three parts. First, there was a competition where the citizens can show what they have done in order to mitigate climate change. The citizens would mail descriptions of specific initiatives to a review committee within the municipality that would evaluate the effort based on its mitigation effect, the extent to which it was carried out collaboratively as well as the level of attention that it could publicly generate. Second, there were activities arranged by the municipality with the purpose of inspiring and informing citizens of what they can do by themselves in order to live environmentally friendly. The content of these activities would subsequently be described on ClimateAwareness as part of the campaign's dissemination. Third, TheClimateParty contained an information campaign based on the cases that the citizens had sent to the municipality as well as knowledge and know-how concerning environmentally friendly living transmitted through local media and the website [TheClimateParty](#).^{vi}

Political discourse

Politically, the campaign was connected to the municipal goal of making Skanderborg Municipality CO₂-neutral with

respect to electricity and heat by year 2020. TheClimateParty can therefore be seen as a result of the administration's implementation of Skanderborg Municipality's climate change action plan.^{vii} According to the climate action plan the municipality intends to increase citizen's energy consumption awareness as a starting point for reductions. The action plan emphasises collaboration with citizens in order to reduce private energy consumption, which accounts for 40 % of the total energy consumption within the municipality.^{viii} Furthermore, the action plan specifically emphasises the possibility that new technology, *in casu* TheClimateParty^{ix} can offer in connection with energy reductions.

Skilled actors

According to the double sided arrows in the Contextual NeMT there are two relevant groups of skilled actors that make up the environmentally sustainable participatory practice involving TheClimateParty as illustrated below in Figure 3.

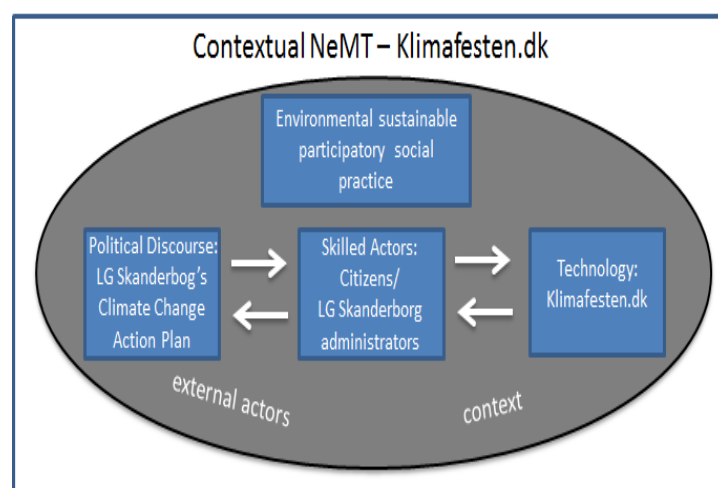


Figure 3: Contextual NeMT – TheClimateParty

Reading the figure from left to right, the political discourse places demands on skilled actors, who are Local Government Skanderborg's climate change administrators. These administrators chose to develop TheClimateParty in order to promote energy reductions among citizens [25]. Alternatively, the figure may be read from right to left beginning with the technology – *in casu* TheClimateParty – which creates the basis for skilled actors who in this case are citizens that are interested in climate change. Their engagement in the campaign creates the basis for realising the targets in a municipal climate change action plan (ibid.).

TheClimateParty and citizen participation

TheClimateParty, which was a municipal climate change mitigation information campaign, contained three core elements that provided affordances for citizen participation in this area. The campaign encouraged citizens to enter descriptions of climate change mitigation initiatives thereby encouraging participation. The best of these initiatives were gathered by the local government who disseminated them to the citizens through the campaign's website thereby creating a form of dialogue. In order to facilitate and encourage citizen

participation the municipality arranged activities aimed at inspiring the citizens to live environmentally friendly. The local government climate change manager would use the citizen dialogue in the continuous development of Skanderborg's environmental policy development.^x Thus, the citizen participation had two purposes: First, it should function as an instrument to help the municipality reach its goals concerning CO₂-neutrality with respect to electricity and heat by year 2020. Second, it should provide material for the continuous development of the municipality's climate change policies.

TheClimateParty's participation affordances aim at motivating citizens to become environmentally friendly in order to help the municipality to meet its goals concerning carbon neutrality thereby in principle matching the affordances of ClimateAwareness. However, on top of this, the campaign also function as a feeding mechanism which should inspire the local climate change manager to continuously develop the local climate change action plan, thereby enabling two-way communication. This strengthens the problem-solving capacity of the municipality, and due to this feature TheClimateParty's participation affordances are considered to be more extensive than ClimateAwareness's.

TheClimateParty has also functioned effectively concerning citizen participation. There were many inputs sent from citizens to TheClimateParty containing novel and creative climate change mitigation suggestions.^{xi} These inputs were reviewed by (among others) administrators facilitating activities in relation to TheClimateParty in order to cross-fertilize on-line and off-line activities. Thus, compared to ClimateAwareness, the administrators behind TheClimateParty have been/are more active, which has increased the levels of citizen participation. Although TheClimateParty technologically speaking is a relative unsophisticated website developed for a single campaign the administrators behind it have been able to involve citizens through other activities coordinated with the help of the application (Møllenbach & Hornbæk 2015).

TheClimateParty is more advanced than ClimateAwareness. The application enables citizen participation at a larger scale thereby expanding the scope of governmental action. This would have been difficult to achieve without the website. This means that the governmental administrator's function becomes one of providing knowledge-based services and service-oriented tasks that address citizens' as well as governmental needs directly.

C. UrgentEvoke

Technology

Citing [26] UrgentEvoke is "a social network game developed by the World Bank. The purpose of UrgentEvoke is to engage ordinary citizens in the fight against global wicked problems, e.g. climate change. The intention of the game is to transform the initial game motivation of the players into a post-game social participation in the form of social innovations in the physical world.

The narrative of the game is the story of a secret social network of international agents with innovative superpowers capable of solving some of the most complex problems facing the international community *in casu* climate change. As a player you are a member of a network, and together with other players you are expected to help find solutions to the missions connected to the ten chapters in the graphic novel. The size and the complexity of the missions makes it difficult for players to tackle them alone and they are compelled to start co-operating and share their knowledge, experiences and ideas with other players. The last mission that players are asked to complete is writing a detailed and innovative plan of how the player will tackle a self-chosen socio-political challenge – e.g. in relation to climate change – in the physical world after the game has ended. This plan is called an Evokation."

Political discourse

In the case of UrgentEvoke World Bank's political aim was to engage ordinary citizens in the fight against the wicked problems that the World Bank is dealing with such as e.g. poverty, hunger and climate change. The World Bank's goal for the players was to '*investigate the most pressing challenges around the world, collaborate to generate innovative and creative solutions, and act to turn ideas into reality within their own communities and beyond*'^{xii}. Thus, their policy operates at the global level compared to the national or local level embodied within ClimateAwareness and TheClimateParty.

Skilled actors

As described previously there are different groups of skilled actors according to the Contextual NeMT depending on which way the arrows in the figure is followed according to Figure 4 below.

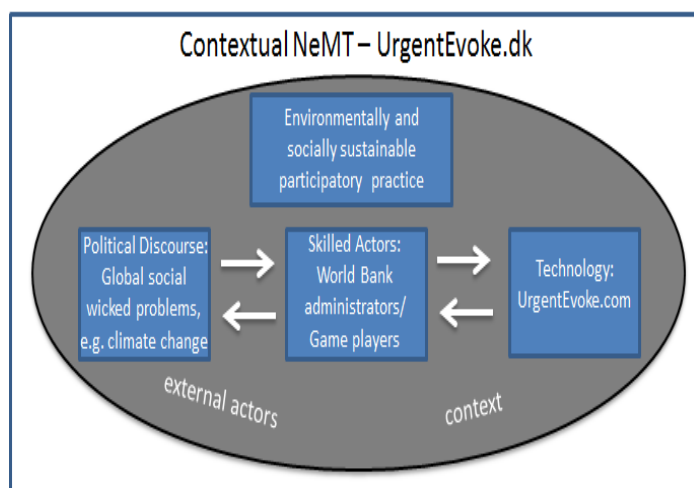


Figure 4: UrgentEvokes.com citizen participation affordances

Reading the figure from left to right, policies within World Bank placed demand on the technology that its administrators implemented and facilitated. The role of the administrators was to review the admissions sent by the players as well as manage the game in collaboration with game professionals that developed the game technologically as well as narratively [26]. Reading the figure in the other direction from right to left the skilled actors were the game players of which there were different types, which is addressed below.

UrgentEvokes.com and citizen participation

The game's participation affordances are more complex than ClimateAwareness and TheClimateParty. The technology itself consists of a website used to communicate the narrative in form of a graphic novel to the players. When the players have solved a mission they have to send their answer to the review committee in the form of a video, document or pictures.

The primary aim of citizen participation of UrgentEvoke is the development of individual as well as community based competences – or unique ‘innovation super powers’ - which can be employed in social innovation relevant for addressing climate change.^{xiii} There were 171,958 individuals who visited the game but only 73 players ended up turning in an ‘Evocation’ and thereby showing the form of engagement the World Bank was looking for. This could indicate that the World Bank did not achieve the citizen participation that they had hoped for [26]. However, despite this the World Bank considered the game a success according to the evaluation: ‘[...] in addition to 19.000 registered players, approximately 80,000 repeat visitors also participated in EVOKE by repeatedly visiting the site to read the graphic novel, read blog posts and linked web resources, and view photos and videos.’^{xiv} Also from an academic point of view this is worth recognising as citizen participation: ‘Urgent Evoke as a success is because they have recognized the important role that the ‘lurkers’ [passive users] are playing for the well-being and development of the gaming community and the fostering of creators’ [26:13].

UrgentEvoke empowers citizens by giving them ‘innovation super powers’ through a serious social web application. It is a highly advanced application that operates at multiple citizen participation levels. At the highest level there are citizens who, by completing the ‘Evocation’ become certified social innovators. However, their achievement would not have been possible without the other 19.000 players and 80.000 repeat visitors. All of these participators constitute a co-creation network that would not have been possible without the web technology.

VII. CONCLUSION

This paper has studied how the affordances of green web applications enable different levels of citizen participation in environmentally sustainable practices.

The affordances of ClimateAwareness was translated into *one-way participation*. Users can implement energy saving guides as well as enter into climate battles at the community level. We characterized this as participation at a basic level.

The affordances of TheClimateParty enabled dialogue with citizens who could send suggestions for climate change mitigation initiatives to the municipality. These suggestions were reviewed, and the best were disseminated to citizens through the website. Skilled administrators would, using the website, arrange other form of activities. Thus, the website and the activities surrounding the website would work synergistically concerning citizen participation thereby demonstrating the importance of skilled actors in the shape of municipal administrators.

The affordances of UrgentEvoke were translated into relative few full bodied participation processes (‘Evocation’s). Instead there were many micro-contributions, which are important for the Evocations, and therefore also deserve acknowledgement according to [26]. The primary explanation for these micro contributions were the graphic novel embodied within UrgentEvoke, which attracted a large volume of passive users. These users were important because they played a variety of active roles in different stages of the game, and even though the micro-contributors did not intend to become players or creators in the game their mini contributions had an impact on the results of the game and on the process of the creators.

Concerning the research question we set forth in the introduction we can answer it in the affirmative. Yes, the affordances of the green web applications we have analyzed do enable different levels of citizen participation in environmentally sustainable practices. However, we also saw, that there is not necessarily a 1:1 correspondence between the affordances and the level of participation. Thus, a real increase in participation demands an active involvement of skilled actors. Our theoretical model (the CNeMT) served to highlight this point, and also made us aware that there are different types of skilled actors; namely citizens themselves and web- or game administrators. Not least the last category is important if participation is to really take off.

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ⁱ The web address for this application is www.klimabevidst.dk. 'Klimabevidst' translates into ClimateAwareness.

ⁱⁱ In Danish the website was named www.klimafesten.dk. 'Klimafesten' translates into TheClimateParty.

ⁱⁱⁱ There is a play on words involved here, as NeMT (nemt) means 'easy' in Danish. The connotation is that this is an easy-to-use model.

^{iv} Quote from Klimafesten: <http://voresomstilling.dk/projekt/klimafesten/107>

^v Quote from Klimafesten: <http://voresomstilling.dk/projekt/klimafesten/107>

^{vi} From: <http://voresomstilling.dk/projekt/klimafesten/107>

^{vii} Local Government Skanderborgs' climate change action plan: https://www.skanderborg.dk/Files/Billeder/PlanErhverv/klimaplan/Politik/Klimapolitik_net.pdf

^{viii} <http://voresomstilling.dk/projekt/klimafesten/107> and https://www.skanderborg.dk/Files/Billeder/PlanErhverv/klimaplan/Politik/Klimapolitik_net.pdf

^{ix} Local Government Skanderborgs' climate change action plan page 9:

https://www.skanderborg.dk/Files/Billeder/PlanErhverv/klimaplan/Politik/Klimapolitik_net.pdf

^x Based on interview with Climate Change Manager Susanne Skårup from Local Government Skanderborg, 20 September 2012.

^{xi} Climate change mitigation examples sent from children to klimafesten. <https://www.skanderborg.dk/Borger/Natur-og-miljoe/Klima-og-bAeredygtighed/Fotos-Jeg-vil.aspx>

^{xii} UrgentEvoke.com evaluation: <http://siteresources.worldbank.org/EDUCATION/Resources/ProjectEVOKE-evaluation-final-16oct11.pdf>

^{xiii} UrgentEvoke.com evaluation: <http://siteresources.worldbank.org/EDUCATION/Resources/ProjectEVOKE-evaluation-final-16oct11.pdf>

^{xiv} Page 17 in UrgentEvoke.com evaluation: <http://siteresources.worldbank.org/EDUCATION/Resources/ProjectEVOKE-evaluation-final-16oct11.pdf>

Energy implications of residential energy monitoring systems

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Abstract— *Smart meter roll-outs are under way and end users are increasingly installing energy monitoring systems (EMS). A comprehensive estimate of efficiency has to include the power use of the infrastructure itself as there may be trade-offs. This applied paper will present the related undertakings in the current IEA-4E Electronic Devices and Networks Annex (EDNA). It will look to describe the features of commonly available systems, present results from an energy measurement of at least one representative EMS and develop user scenarios to identify the possible range of energy consumption of these systems.*

Keywords— *energy monitoring system; energy consumption; IEA; 4E; EDNA*

I. INTRODUCTION

The EU Energy Efficiency Directive 2012/27/EU and its national implementation in the form of national energy efficiency laws, promotes the introduction of smart meter infrastructure (SMI) and energy monitoring systems (EMS). As a result, smart meter roll-outs are under way and end users are increasingly installing energy monitoring systems (EMS) to better understand and manage the energy consumption of appliances in their homes.

In this context, the SMI consists of the smart meter (SM) and everything needed for the SM to communicate with a Distribution System Operator (DSO). The EMS on the other hand is a system used to visualise the electrical energy consumption in a household to the consumer. This information has to be accessible to the user in almost real-time and/or on-demand. The data should include the current consumption as well as logged data. Regular billing intervals (e.g. monthly) do not constitute an EMS because the data is neither available in almost real-time nor on demand.

Policy makers expect that, in the short term, these measures will increase the energy efficiency of households, by providing the user with relevant information to make more informed decisions. The hypothesis that improved feedback will have both immediate (motivational) and longer-term (learning) effects on energy use is supported by a large number of studies. On average, the effect is typically of the order of a few per cent compared with households without the feedback [1].

II. OBJECTIVES

Providing feedback on energy consumption however requires suitable hardware which has to be supplied with power. A bi-National technical comparison, undertaken between 2010 and 2012 in Austria and Switzerland regarding the energy consumption of the planned smart metering infrastructure, showed that depending on the technology, SMI can have considerable own energy consumption [2]. A comprehensive estimate of efficiency has to include the power use of the infrastructure itself, as there might be trade-offs between the energy consumption resulting from the deployment of smart metering and EMS infrastructure, and the potential gains at the consumer side.

The currently available EMS are often part of, or integrated into home automation systems which offer additional functionalities beyond energy monitoring. Positive changes from user behaviour may therefore be offset by the energy consumption of the (numerous) additional components and functions offered by these systems. This project of the Electronic Devices and Networks Annex (EDNA), of the International Energy Agency IEA - 4E [3], explores these issues and considers the magnitude of the impact of installing smart metering and energy monitoring systems. Key issues under research are:

- Identify the energy consumption ranges of the different smart metering infrastructure and energy monitoring systems as well as influencing parameters; both at the components level, and systems as a whole.
- Categorize and classify the functionality of the SMI/EMS as basis for possible comparisons
- Extrapolate the measured data into “roll-out scenarios” for different countries, to identify the scope of potential improvements. The potential for policy interventions by governments within the SMI/EMS market to encourage efficient technologies and solutions should be explored.

III. ACTIONS

The key actions in this project are:

- Researching SMI/EMS technologies and systems present in the market. This information will help classify the systems and their functionality, to enable the comparisons of their power use (such as provision of two-way communications, control, flexible tariffs, power quality monitoring, and the end user functionality for home monitoring devices such as handhelds, in-home display, or web portals).
- Measuring and reporting the energy use of different SMI/EMS technologies, so that comparisons can be made of the different implementations of these systems.
- Developing a flexible and broadly applicable assessment methodology, combining the research results with the measurement data, to extrapolate plausible scenarios and their energy consumption implications.
- Engaging with stakeholders, including manufacturers, standardization organizations, energy agencies, energy utilities, and communities/networks dealing with smart metering and energy monitoring systems.
- Identifying market trends on future energy monitoring technologies and their functionalities at an early stage so as to enhance global collaboration at the scientific and policy level.
- Identifying focus areas and scope for policy development (e.g., energy consumption relevant features and functions)

IV. OUTCOMES

This applied paper will concentrate on selected results from the EDNA project, looking at the features of commonly available EMS, and presenting results from at least one energy measurement of a representative EMS. User scenarios will be developed to identify the possible range of energy consumption of these systems.

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GSBLapp: Tailored Chemical Substance Information for Arbitrary On-Site Usage on Mobile Devices

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Abstract—Technical assistance for the provision of substance information for firefighters, specialist consultants and rescue services replaces more and more conventional, paper-based solutions. Recently, the Federal Environment Agency of Germany developed a mobile application for smart phones and tablets specially tailored to the needs of firefighters. This so called GSAapp allows users to efficiently and instantly search offline for information on 16000 substances. We realized soon that there are additional possibilities of use for chemical substance data and relevant chemicals-related legislation on mobile devices. However, we noted that required techniques and functionality are similar for such applications. Therefore, we developed one mobile application that is customizable for different scenarios. We present the approach and our results in this paper.

I. INTRODUCTION

The Joint Substance Data Pool of the German Federal Government and Federal States (GSBL) [3] is a continuously maintained, uniform collection of validated information on chemical substances, held in a central national database. The mission of the cooperation is to provide public authorities and the general public with reliable, topical chemicals information in support of all activities to prevent and avert danger and to protect humans and the environment. Records contain information on physical and chemical properties, on ecotoxicological and toxicological parameters and on environmental fate. They provide descriptions of environmental hazards, health dangers, fire and other technical hazards and give information on relevant chemicals-related legislation. Responsibility for operating the system lays with the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Environmental Ministries of the Federal States (Länder). The cooperation was established through an administrative agreement in 1994.

The Hazardous Substances Rapid Information System (GSA) is a component of the GSBL which contains relevant data specifically for rescue services. In 2014, a view for displaying on PCs was developed especially for firefighters, specialist consultants and rescue services. Due to this successful project, the Federal Environment Agency of Germany (UBA), additionally, developed a mobile version specially tailored to the needs of firefighters, called *GSAapp* [4]. This mobile version allows different emergency forces on the spot and in case of crisis or disaster to efficiently search offline for information based on 16000 substances. GSAapp can be installed on smart phones and tablets with

the operating systems Android and Apple's iOS.

While developing GSAapp, we realized soon that there are additional possibilities of use for chemical substance data and relevant chemicals-related legislation for on-site application on mobile devices such as consumers and health protections, food control and occupational safety. Since, we assume some more use cases and we do not want to develop one mobile application for every scenario as well as practicability should be tested before publishing, one customizable mobile application (*GSBLapp*) was developed and tested as a prototype.

The process of realization is pictured in the research presented here.

II. REQUIREMENTS

Since, we already have experience in developing an application for mobile devices and our expectations for the GSBLapp prototype are known, deduction of requirements and identification of potential issues for a similar mobile application are easier to accomplish. Moreover, we already have an intuitive usable mobile application (GSAapp) and existing users got used to it. We do not want them to relearn proper handling.

- 1) Usability and surface feel should be similar to the GSAapp and
- 2) both screen modes (portrait and landscape) have to be supported.

Even though the common interface standard for GSBL is determined to the proprietary, self-invented SSF format (Standard-Schnittstellenformat),

- 3) data should be loaded in XML format,
- 4) one data package can be loaded simultaneously and
- 5) data package are replaceable.

Currently, the major part of GSBL's substance data is only accessible to public authorities due to publication rights. Hence, GSAapp as well as the GSBLapp are not made freely available.

- 6) GSBLapp and GSBL's data packages need to be online available via authentication.

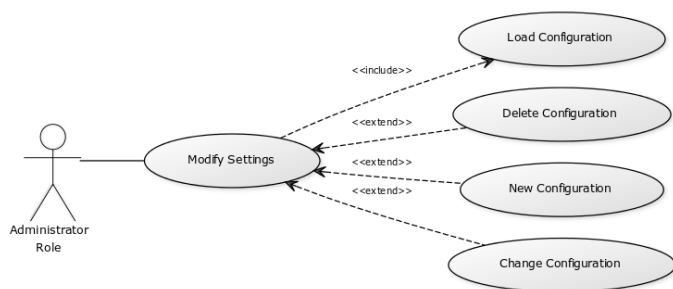


Fig. 1. Administrativ use case for modifying configurations

Since, we want to create a prototype where cost burden should be reduced to a minimum and open standards are favored, we determine to use

- 7) Android as development platform and
- 8) allow usage on tablets as well as smart phones.

Due to the fact that we want to develop only one mobile application which can be used for all application scenarios based on GSBL's chemical substance data, GSBLapp needs a

- 9) freely customizable search mask and
- 10) user-group-specific result presentation as well as
- 11) storage capabilities for any substance datasets (schema-free).

Finally, we have to emphasize that all mentioned requirements are results arose by general needs and none of these issues is key user specific. Since, their individual requirements on data presentation shall be regarded by the configuration designing process within the GSBLapp.

III. BASIC CONCEPTION

Derived from requirements mentioned above, objectives for the development of the GSBLapp are clearly framed. We want to develop one mobile application which can be used for all application scenarios based on GSBL's chemical substance data. GSBLapp also needs to be configurable as well as provide information for search requests. This means in particular that we will have two kinds of user roles, respectively, distinguishable user intensions.

- *Administrator role* configures search mask and result presentation according to field of application and key user interests.
- *Key user role* utilizes predefined configuration to search and to obtain results for a search request.

Since, not every key user has technical skills, both role may be taken by one person, but do not have to. Therefore, we decided not to mix up both intensions and hide administrative functions as far as possible in order to encourage non-technical people (key users). For further use, we call the predefined configuration to search and to obtain results for a search request as *frontend* and the configuration interface as *backend*. Even though, the backend is only hidden on the first glance, but accessible for everyone without login.

To design the general concept and collect all must-have

Fig. 2. Predefined search mask with three search boxes

functions for the application, we chose *use cases* [8] as the important requirement technique. In addition, due to the fact that we distinguish two user roles, use cases were also separately ascertained. Overall, we gathered 21 use cases in close collaboration with potential key users (e.g., chemists, analysts and biologists) and individuals with technical skills (computer scientist). Use cases that contain modifications of a configuration (search mask and result presentation) have also been captured just like procedures of searching and result presentation. Figure 1 depicts one schematic example of an administrative use case. Within further development of conception, we additionally noticed some more technical requirements which will be very important during the implementation process.

IV. IMPLEMENTATION PROCESS

Because Android was preselected as development platform, we only needed to choose an appropriate development environment. Finally, we decided to use Eclipse [1] with Android Development Tool (ADT) [2] plugin, since, it is free to use and we already had some experience with Eclipse. Moreover, ADT extends the capabilities of Eclipse in a way that we can easily create an application user interface, add packages based on the Android Framework API and export .apk files for demanded distribution purpose.

Most challenging was to identify an appropriate database solution, because commonly used and by default included file-based database SQLite (sqlite3) [5] has a substantial shortcoming: it is relational. But the majority of our substance datasets does not have a rigid data layout. Most substance records are schema-free and can be arbitrary shaped. Only after storing all the data, the user (in administrator role) has to decide which attributes should be searchable and visible on the detailed substance presentation view. Therefore, we identified as a suitable alternative CouchBase Lite [7]. It is a fully functional, lightweight, native, embedded NoSQL database (JSON [6] based) that can work standalone and lives

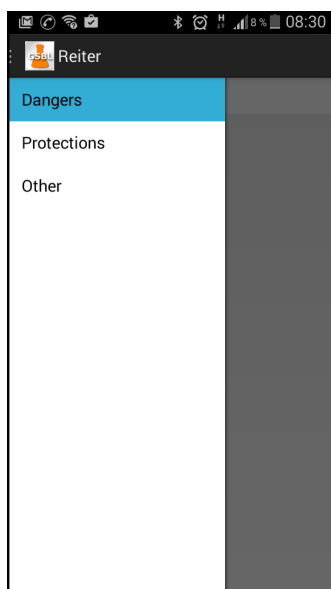


Fig. 3. "Fire" configuration with three tabs and substance attributes

locally (offline) on mobile devices. In addition, CouchBase Lite is well supported and has a detailed installation manual including Couchbase Lite project instructions for Eclipse, which reduces set-up time significantly.

As demanded, we split the GSBLapp into two functional distinct operating modes: frontend and backend. After the application starts, GSBLapp always loads the frontend and present a predefined search mask to the user (see Fig. 2). At this point, search requests can be submitted and data is afterwards displayed in a preconfigured result presentation. In case no configuration exists a message is prompted with the instruction to set up a configuration before work may continue. Backend can be easily reached by first clicking menu-button on the respective device. Subsequently, option "settings" will be displayed which is the entry point for the backend. By simply quitting any configuration process at every time the user is taken back to the frontend (for key users) by default. All changes are automatically stored and applied to current session as well as for further use. One configuration always consists of at least one tab that holds again a minimum of one substance attribute. Names of attributes are included in the current loaded data package whereas configurations and tabs can be named individually. Figure 3 depicts an example of a configuration "fire" which has three tabs called "Dangers", "Protections" and "Other". Each tab itself contains of several substance attributes. To be able to search efficiently, database search indexes are set immediately after determination of search attributes.

V. CONCLUSION AND FUTURE WORK

So far, our developers did amazing work and the prototype is fully functional, even though, there is still potential for improvement. However, differentiated by subject area and evaluated by experts (chemists, biologists, firefighters, etc.) all enforced requirements have been fulfilled and the usability is intuitional. Despite that we faced several issues while implementation, development time was hardly exceeded.

Nevertheless, we recognized afterwards some improvable circumstances. Beside performance optimizations, we have to implement a more optimal search algorithm, since at present, we only do a simple text comparisons without any wildcard options. Furthermore, loading of data packages is currently not encrypted. Another point of criticism is related to the storage configuration. Prospective, configuration should be exchangeable between different devices and, therefore, a configuration handling and storing on the mobile device's file system has to be implemented. However, given the fact that a prototype was demanded, we are very satisfied with the outcome.

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INSPIRE or INSPIREd eReporting?

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Abstract – Environmental reporting is subject of a process of continues changes, which has content and procedural aspects. In the terms of reporting mechanism the technologies introduced by the INSPIRE Directive are the main driver. While the INSPIRE Directive clearly defines service and data specifications it's reuse for the purpose of environmental reporting leaves some principle design questions unanswered. This paper shall discuss different approaches and reflect on existing examples for environmental monitoring reusing INSPIRE elements.

Keywords – Environmental Reporting, INSPIRE, eReporting

I. INTRODUCTION

Environmental reporting is facing a phase of increased changes. While the adoptions were so far mainly limited to changes of content requirements the INSPIRE Directive (2007/2/EC) becomes a main driver in terms of technological changes. The INSPIRE Directive is among others asking public authorities to provide their relevant data by using specified web services and data specifications, which should support the cross-domain integration of data.

It is a logical consequence to apply the technological changes introduced by the INSPIRE Directive to environmental reporting which is commonly address using the term “eReporting”. But while the first implementation of eReporting in the area of air quality is manifesting other design approaches become visible. This highlights the need for a broader discussion about and testing of environmental reporting approaches using elements of the INSPIRE Directive specifications. Beside best practices on the technical side it also needs a wider discussion on the expected and hitherto manifested benefits of the different approaches.

II. EREPORTING APPROACHES

From the design and implementation examples today we can derive two major scenarios, the one integrating INSPIRE elements while the others links reporting data to the respective INSPIRE data set.

A. Integrated approach

The earliest example regarding the re-usage of INSPIRE Directive specifications for the purpose of environmental reporting is the recent adoption of the reporting provisions for air quality. The rules for the reciprocal exchange of information and reporting on ambient air quality for Directives

2004/107/EC and 2008/50/EC of the European Parliament and of the Council are set out in the COMMISSION IMPLEMENTING DECISION 2011/850/EU and Commission's guidance documents IPR guidance part I [1] and IPR guidance part II [2].

The air quality eReporting example is using an approach which is generally based on the extension of the respective INSPIRE data specifications to meet the thematic requirements. The result is a number of XML schemas which each individually is covering the both needs, from the INSPIRE Directive and air quality content requirements [3].

Some benefits of this approach already materialized (e.g. consolidated data model, reuse of existing standards or machine readable reporting format) while others are still expected. In the current implementation the final step is still missing, the service based provision of reporting data. Only with this step the data flow can be lifted up from the bilateral exchange to a service based approach accessible to multiple user-groups which takes advantage of the near real time characteristic of some of the air quality content.

B. Linked approach

In contradiction to the integrated approach introduced by the air quality example an alternative scenario builds on a linked data approach between reporting and INSPIRE data. This scenario is lacking implementation cases so far, but the main motivation for it is to design a lightweight reporting mechanism which is simpler than the full integration but still takes advantage of the INSPIRE Directive's specifications.

The general idea of this linked approach is to keep reporting data separated from the INSPIRE data sets, but reference to them if needed. This approach would take advantage of data sets provided according to the INSPIRE Directive's specifications which public authorities have to provide in any case to fulfill their legal obligations. The content information would reference to the INSPIRE data sets were possible but try to avoid redundancies. The design, complexity and provision of the content information would depend on the actual reporting case, update frequency and the re-use potential beyond the pure reporting purpose.

On the yet hypothetical example of CDDA reporting [4] this approach would mean that the reporting design and obligation would include two major modules. One the one hand the Protected Sites data set compliant with the INSPIRE Directive's specifications and one the other a set of XML

encoded content data which are referencing to the INSPIRE data set where necessary. While for the INSPIRE data sets the respective INSPIRE network service can be harvested the content data sets not necessarily have to, which is a decision which have to be taken in dialog with potential data providers.

III. CONCLUSIONS

With the variety of reporting obligations and flow comes a variety of possible reporting approaches. The actual design of the reporting mechanism should be flexible taking into account the limited resources of data providers, update frequency, legal aspects and the reuse potential of the reported data. For smart decision making on the reporting approach furthermore best practices on different approaches and options are needed.

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Interoperability of Environmental Data with a European Information Platform for Chemical Monitoring (IPCheM)

Data management across the disciplines

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Abstract: Monitoring programs in Germany offer a large variety of data. On the one hand, these data are generated over many years in selected sampling areas; on the other hand, studies of monitoring take place in the context of research projects or other investigations. These data are often available in web-based information systems. Two databases will be presented with their potential for the interoperability with a (technical) platform for data of the chemical monitoring. The European project "Information Platform for Chemical Monitoring (IPCheM)" promotes networking of various existing databases and information systems with the goal of advancing the environmental data exchange between different disciplines.

Keywords: *monitoring; human biomonitoring; German Environmental Specimen Bank; POP-Dioxin Database; IPCheM, integration, PCB, Bisphenol A, Dioxin*

I. INTRODUCTION

Monitoring programs in Germany offer a large variety of data. On the one hand, these data are generated over many years in selected sampling areas; on the other hand, studies of monitoring take place in the context of research projects or other investigations. These data are often available in web-based information systems, and can be publicly searched for various issues. Two of these are the German Environmental Specimen Bank (ESB) and the POP-Dioxin Database of the Federation and Laender (Federal States) (POP-DB) which allow interoperability between several platforms. The EU-project "Information Platform for Chemical Monitoring (IPCheM)" financed by the Commission of Environment (DG Env) promotes interoperability of various existing databases and information systems with the aim of advancing the environmental data access between different disciplines. From a scientific point of view, this European research project contributes to the implementation of the European eGovernance Strategy. The Joint Research Centre in Ispra (JRC) is responsible inter alia for the technical solution and coordination of this project.

II. DATA AND METHODS

A. POP-Dioxin Database

The POP-Dioxin Database of the Federation and Laender (Federal States) represents a central portal that provides access to results of national and international measurement programs and research projects for the substance group of Persistent Organic Pollutants (POPs). For more than 15 years, data from approximately 100 monitoring programs of Federal and Laender Agencies and Research Institutes have been stored in the database, accessible via a web-based service interface (<http://www.dioxindb.de/index-e.html>).

The metadata - data about data - are an essential issue for an integrated approach to evaluation and assessment. Information on sampling, spatial and time references, and methodologies from the environmental compartments soil water, air, biota (plant and animal life in nature), products, food and animal feed, breast milk as well as other areas are the basis for the derivation of temporal and spatial trends [1].

The POP- Dioxin Database uses various IT tools whose development and networking concepts are explained in detail here (http://www.dioxindb.de/f_daten_db_e.html).

Using the eXtensible Markup Language, information can be exchanged between databases of different model concepts. The approach of the free, platform- and implementation-independent exchange of data of the POP-Dioxin Database is one of the important issues which fit the requirements of an open interface for environmental data, and the interoperability between several platforms.

B. The German Environmental Specimen Bank

The German Environmental Specimen Bank (ESB) is a specialised environmental monitoring program, which collects and archives environmental and human specimens. It is a major component of the German environmental observation system. In the 1980s the German ESB started to systematically collect samples from the environment and human populations.

A general concept [2] and more specific standard operating procedures (SOP) define where, when and which specimen and matrices should be taken, and which measurements have to be carried out regularly. The measurements cover chemical analyses, biometric and anamnestic data, but also metadata logging the sampling circumstances. After sampling, the samples are deep frozen and stored long-term for retrospective analyses.

Both the results of the annual investigation program and the results of retrospective trend analyses are published on the ESB public website along with the data and additional information (www.umweltprobenbank.de). Retrospective analyses cover substances like perfluorinated compounds, biocides, phthalates, and bisphenol A.

Networking in the ESB community has a long tradition and focuses on two aspects: harmonization of scientific methods and data interchange and integration. In 2008, the *International Environmental Specimen Bank Group* (IESB) was launched and set up a joint website to promote and share ideas among ESBs and interested parties (<http://www.inter-esb.org>) [3].

III. INTEROPERABILITY OF IPCHEM

The EU project "Information Platform for Chemical Monitoring (IPChem)" establishes a direct and tailor-made link to data collections. Providers maintain databases' structure, while combining their knowledge and rendering it accessible for search and retrieval through a unique interface. This creates larger visibility and promotes a wider use of valuable chemical monitoring data, thus amplifying the knowledge base for a sound risk management and communication. Combining information from different sources on a variety of environmental media, consumer products, food, and ultimately from human beings themselves, provides the basis for understanding combined exposure and the effects of chemical mixtures [4] [5].

IPChem is structured into four modules based on the group type of chemical monitoring data. For the module 'environmental monitoring data' the Federal Environment Agency (UBA) provided metadata and analytical data of the

substance group Polychlorinated Biphenyls (PCB) enabling the project team of JRC to test the methodology for the IT solution. First results were presented on a workshop in December 2014 [6].

For the ESB the data are already publicly accessible via a single access point [7] – so, why would we like to contribute these data to the platform of IPChem? From our point of view, IPChem, with its single access point to locate and retrieve chemical monitoring data from different data providers, gives us the chance to make the data known beyond the specimen bank and human biomonitoring communities. This means added value for our investigations and both the public and the scientific community would have the chance to profit from our data. Because a platform for data interchange is still missing in 2015, IPChem could be a chance to fill this gap - at least for the European ESBs.

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Quo vadis – INSPIRE?

An entirely new approach to environmental data management – sustainable, scalable
expandable and interoperable –
described on a practical project in Saarland including the data provision for INSPIRE

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Abstract—Environmental data are usually subject-specific structured and incompatible for multidisciplinary applications. INSPIRE itself has thematically tailored data models. We miss a Theme Crossed approach for environmental data management. This presentation shows how a harmonized data management can be constructed and how the environmental data can be made available according to the INSPIRE definitions of Annex III.

Key Words—environmental data, INSPIRE, Annex III, reporting, harmonized data management, Theme Crossed approach, system analysis of ecosystem, sustainability, INSPIRE.Insight

I. INSPIRE AND ENVIRONMENTAL AUTHORITIES – A CRITICAL VIEW

- INSPIRE does not support the actual work of the environmental authorities.
- Not even the environmental reporting is supported.
- INSPIRE data models do not help to organize a Theme Crossed harmonization of the environmental data management.
- The chosen approach for modelling is contrary to the working method of environmental authorities.
- The models are incomprehensible.
- INSPIRE is an additional duty – without advantages in their work.

II. REQUIREMENTS FOR THE MANAGEMENT OF ENVIRONMENTAL DATA

In as-is-analyses in Saarland, we found more than 1.000 shp-files, more than 100 applications, no harmonization, inconsistencies and no interoperability between the thematically separated data collections.

Environmental data are mass produced data subjected to dynamic and extensive expert processing and administration:

- Permanent change of requests and demands of data to be captured and processed
- Interdisciplinary analyses, frequently adapted to political requirements
- Generation and administration of time reference data.

III. THE IDEA

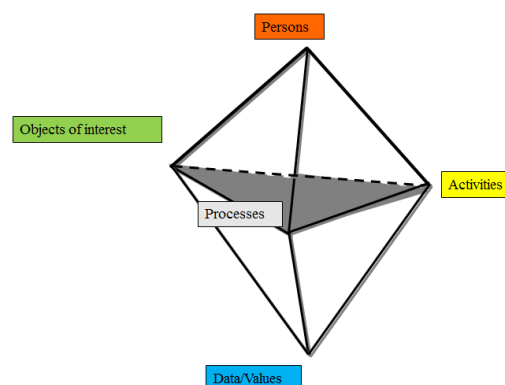
In the past data processing was focused on a simplification and automation of the specific work processes. Today we can find other approaches: the creation of authentic representations of our reality (e.g. in Google), enriched with assessments, forecasts, simulations etc. For this image we must manage complex data structures with difficult cause-effect-relationships between all environmental spheres. Using this data basis, smart applications are developed and distributed (e.g. Apps).

In my understanding INSPIRE offers the opportunity for the environmental authorities to provide their data for these advanced technologies.

IV. THE MATHEMATICAL APPROACH

In the GIS world the geometry is the object defining characteristic. With this method we are not able to depict the environmental reality with its processes. That's why my approach represents one real object as exactly one information object. And all information objects can have any geometry and exists in time.

Therefore I developed a Theme Crossed understanding of the environmental processes with a new thematic approach to describe the environmental system: The data model is neither based on reporting templates and INSPIRE, nor on geometric aspects - but on mathematical system analysis of the ecosystem.



As a result of the system analysis I created a classification of the objects, resulting in a data model in the form of a

tetrahedron. The vertexes are “objects of interest” (e.g. technical facilities, protected sites, monitoring facilities), as well as “environmental processes” (e.g. storage/conversion of materials and energy) and “activities” (e.g. observations, measurements, approvals) – and all these object classes can exist in space and time.

V. THE MODELLING APPROACH

The current modelling methodology is not appropriate to design a Theme Crossed and interoperable depiction of the environment – but we find very specific models for every theme (e.g. INSPIRE Annex III). This induces a patchwork of data structures.

Thus I created a methodology using UML to model in two stages:

A. *The reality*

A system analysis model to describe the reality according to the tetrahedron: This kind of modelling offers the possibility to expand into further environmental themes while maintaining the scope on interoperability.

B. *The use cases*

Separate data models to describe use cases: This kind of modelling offers the possibility to define different views on a single system analysis model.

This entirely new approach can satisfy all reporting duties and customer requirements with one (!) “reality-model” and different “use-case-models”. The methodology is explained in detail in [1]. Practical solutions are described in [2], [3] and [4].

VI. PRACTICAL REALIZATION IN SAARLAND

Saarland built up a Theme Crossed data center according to the modelling methodology described above.

- SDI-Saarland is the central spatial data node for the Environmental Department.
- The information system collects data from the different units, which have relevance for other departments as well.
- The data is structured in a consistent way regardless of its origin.
- SDI Saarland uses one interoperable, expandable data base – the “reality-model”. All information for the different use cases, including reports, is collected from this data base.

VII. INSPIRE INCLUDED

Obviously the availability of environmental data can be used for INSPIRE:

The contents and the amount of the data for the thematic tasks are substantially larger than the data specification of INSPIRE requires. That’s why we added some attributes for INSPIRE in our central data base and we created one data pool for all reporting, INSPIRE included.

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Reducing energy demand within large organisations through IT-enabled Behaviour Change

3 case studies from the UK

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Abstract— In the field of energy demand reduction, Behaviour Change has not traditionally been regarded as an easy route to achieving substantial results. Arguably this is driven by perceptions that it is (i) difficult to influence large numbers of people, and (ii) difficult to quantify the potentially nebulous results generated.

This paper proposes that by use of innovative and engaging IT systems, both of these challenges can be addressed. By so doing, Behaviour Change can be systemized and used within large organisations as a useful route to achieving significant reductions in environmental impact. It reviews examples of such Behaviour Change programmes within 3 large organisations within the UK and highlights the impact of the IT-enabled approach.

Keywords— *Behaviour Change; Energy demand reduction; Human computer interaction; Organisational change; Carbon footprint reduction; Case studies*

I. OBJECTIVES

Public Sector organisations within the UK have a legal mandate to reduce their Carbon footprints. In developing their Carbon management plans, most have included staff engagement as an element of their approach.

The author, working with ZapCarbon Ltd., has taken this as an opportunity to develop innovative modular behaviour change systems for such organisations. Novel IT platforms have been central to their successful operation. (Examples at www.cranfieldgreen.co.uk, www.ougogreen.co.uk and www.beeslondon.co.uk)

Programmes on three university campuses are reviewed in this paper (University of London, Open University and Cranfield University). In all cases, programmes have been run for a minimum of 2 years, and the latest results are presented.

By using innovative IT, the aim of the programmes has been to give the organisations cost-effective routes to engage staff, develop their capabilities with regard to environmental improvement and measure the results they achieved.

II. METHODOLOGY

The approach taken focuses on integrating and enabling local “energy champions” by means of innovative IT platforms. The paper includes the iterative design process

behind these online platforms, which was geared to achieving a number of roles, including:

- awareness raising,
- facilitating peer pledging of support
- inter-champion communication
- team building
- fostering competitive spirit towards goals
- tracking energy-saving actions taken
- displaying energy consumption data & resultant changes

Well-designed IT systems have been a key enabler in allowing the programmes to operate in a manner that encourages efficient & effective operation. Not only does champion interaction increase as a result of better engagement, but the unit cost of the programme can be kept low, thereby increasing the return on investment for the organisation.

III. RESULTS

The results from the three sites are presented in this paper.

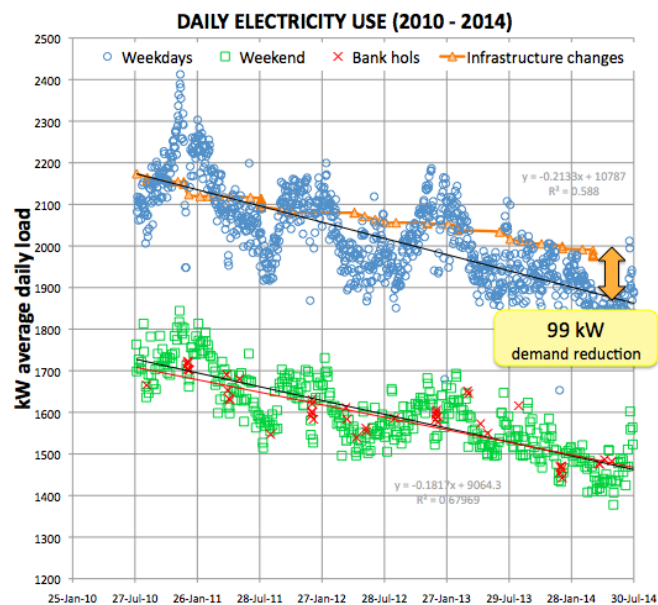
Within all three organisations, the champion density was around 1 - 2% (ie: 1 - 2% of staff population chose to become champions). These champions were given specific tasks, all of which centered around the online platform. The system included automated messaging to mobile phones and results-based feedback in real time.

To raise awareness across the organisation, champions asked fellow staff to pledge their support online. From this action, between 25 – 40% of the organisations’ populations were reached (i.e.: several thousand staff members) and as a consequence, became linked in to the programme’s aims.

Using an online Action monitoring system, champions self-selected energy-saving actions to undertake within their workplaces. When these were performed, champions recorded these on a live Actions Feed. The immediate effect of such actions was a reduction in energy demand. However, the cumulative social effect of displaying the champions’ actions online was to create an enhanced momentum to the programme and competitive motivation between champions.

Reflecting data back to champions on the effects of their actions is a powerful tool. Where metering of energy consumption exists, this is done in close to real time. Champions can thus observe the magnitude of their changes within their workplaces and learn which changes have the greatest energy-saving potential. Many results are presented in which champions have reduced their building's energy consumption by over 20%, and a smaller number where reductions of over 50% have been achieved.

In total, these programmes have saved the organisations substantial amounts of money and avoided CO₂ emissions. Through careful analysis it is shown that the three universities are currently benefitting by over £320,000 / year and 1,300 tonnes of avoided CO₂, as behavioural-led changes have already reduced demand by between 5% and 8%.



IV. CONCLUSIONS

Effecting behaviour change within large organisations has always been difficult owing to the large numbers of people involved, the slow speed of feedback and the difficulty in quantifying results. This work shows that well-designed IT systems are a key enabler in overcoming all of these challenges.

IT has permitted and facilitated the following: Community building, awareness raising, quantification of savings, feedback on actions, competitive activity and rapid reporting. The results from these programmes have helped three universities to cut their electricity consumption by between 5% and 8%, with potential for greater future cuts. Collectively, as a result of this mechanism, the three universities are reducing their environmental impact by over 1,300 tonnes of CO₂ per year.

The implications for other areas of behaviour change are significant. Potentially the lessons learned in these IT-enabled energy reduction initiatives can be translated into other fields (eg: other environmental arenas, organisational change, etc)

Simplifying an application for LCIA by conducting a usability study

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Abstract— This paper describes the methodological background which enables calculation of environmental impact indicators for chemicals without knowledge on their production processes. Subsequently, it is described how these can be calculated in batch mode in order to set up a database containing a large number of chemicals. The project included a usability study. The approach of this study and how it enhanced the overall project outcome is presented.

Keywords— LCA; data gaps; chemicals; usability

I. INTRODUCTION

Data gaps are unavoidable when a complex Life Cycle Assessment (LCA) is conducted. Within the project 'StUChem', a web based database was developed to provide calculated Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) indicators for large numbers of chemicals.

The aim of the project was to enable a broad target group to use the results which were achieved when the so-called FineChem-Tool [1] was developed for environmental impact assessment of chemicals based on their molecular structure. Consequently the project was set up including a usability study to ensure user-friendliness of the developed website.

II. METHODS

A. Approaches to meet data gaps in LCAs

Life Cycle Inventory (LCI) databases (as for example [2]) are commonly used in LCAs to identify the background and thus to set the system boundaries. Though, depending on the subject studied, the availability of data is not always sufficient and especially scarce for chemicals.

While several approaches have been developed to meet data gaps these are mostly connected to high uncertainty while still demanding considerable effort.

Wernet et al. [3] showed that Life Cycle Impact Assessment (LCIA) indicators for chemical compounds, which normally are calculated from a complex material flow network model, can be estimated using Artificial Neural Networks. The Neural Networks were trained to calculate

Global Warming Potential (GWP), Cumulated Energy Demand (CED) and Ecoindicator 99 from a set of molecular descriptors without requiring knowledge about the production process. The results were made freely available as 'FineChem Tool' [1]

B. Use of the FineChem Method

Despite the possibilities to close data gaps by the FineChem method, it did not achieve wide distribution. We assume that this is partly due to the fact that the method asks for molecular descriptors requiring users to have training in chemistry. To our knowledge, work about the FineChem Tool was presented at LCA XIV [4]. Wernet et al. [5] presented an approach to use calculated values for priority-setting. Throughout the course of the project, some interested parties were supplied with calculated LCI(A) values. To our knowledge, no further LCAs using calculated LCIA values of chemicals have been published.

The FineChem approach provides a powerful tool to close data gaps. LCIA data can be estimated quickly and without knowledge on the production process. By automated evaluation of molecular descriptors and thus enabling bulk handling of molecules, this approach was made available for a considerably broader target group. Non-experts on the chemical field are now able to use this approach.

C. Developing the database EstiMol

As the project aimed at enhancing the accessibility of the FineChem approach, the evaluation of the required molecular descriptors was automated. SMiles ARbitrary Target Specification (SMARTS) was identified as a suitable language to count the different functional groups. A Python Script was used in order to enable bulk evaluation. In order to provide a large number of chemicals, [6] was chosen to provide the molecular structures that were used to set up a database for the project. Subsequently, the implemented methods were run on 40,000 molecules for which the indicator values were afterwards calculated using the FineChem-Tool.

For the user interface, the web tool EstiMol was developed. EstiMol features cradle-to-gate GWP, CED and EcoIndicator 99 for roughly 14,000 substances. The workflow starts with an introduction to the methodology of the FineChem-Tool. Users can search the database for chemicals

by either name, trivial name, CAS (Chemical Abstracts Service) Number using a full text search. Furthermore molecular structures can be searched using the chemical editor Marvin [7]. It is integrated in the search page to enable the users to draw molecules. Search results are presented on the following page. For each chemical, the reason why it was found is indicated. By clicking on a substance, the result page is opened. Here, the calculated values, as well as name, CAS numbers and the molecular structure are shown. In the case of molecules not being valid for the FineChem methodology, this information is displayed and the reason is given. The website can be accessed via <http://www.umberto.de/en/estimol/estimol-data/>.

D. Usability Study

At the HTW Berlin, a series of usability studies have already been conducted in the past [8]. In another usability study in April 2014 it was tested if new users can use the frontend of the sustainability search engine for chemicals in an effective, efficient and satisfying way. The case study was performed using the eye tracking method. Particularly the following questions were supposed to be answered:

- Are the users able to find a given substance within 3 minutes?
- How intuitive is the usage of the drawing tool to find a molecule structure?
- How many of the users understand the results page and can name the environmental indicators to a given chemical?

1) Test Settings

To answer these questions, a set of seven tasks was prepared which was conducted by ten test persons. The test persons had basic knowledge of chemistry. The tasks aimed at obtaining different environmental indicators of chemicals by varied ways (full-text search, CAS Number, structure drawing tool).

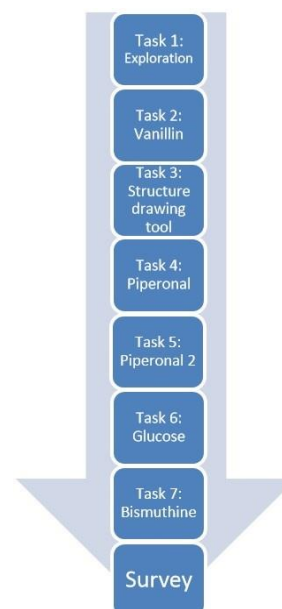


Figure 1: Task sequence of the study

Within these tasks the tool was analyzed according to the three quality attributes defined by [9]. The effectiveness shows the capability of producing a desired result. It is measured by the ratio of how many people completed or failed the tasks. After the task completion the success was evaluated within the categories “with ease”, “with complications” and “failed”. The target value obviously is that every task is passed with ease.

The efficiency shows how quickly users can work on the tasks. It was measured by the time spend to reach the given task goal. For each task a maximum time limit was specified in which the test person should have passed the task.

The satisfaction illustrates how pleasant it is to use the design of the application. It was covered by two questionnaires by use of the AttrakDiff survey of [10] during the study. It is an instrument to measure the hedonic and pragmatic quality of software in the form of semantic differentials. Besides that, the test persons had been motivated to bring in their thoughts using a think aloud protocol. Furthermore they were asked after the test to say three things which they like most and which they don't like (tops & flops).

III. RESULTS

Even though the tool was relatively small and the number of participants not representative, the usability studies discussed here, led to a series of improvements of the software. A catalog with over 50 items of possible enhancements was the main result of the evaluation. The most important information were gathered by the think aloud protocols and the tops and flops questionnaires. It was shown that the most possible enhancements were evaluated by the users while working on the tasks. Some eye-catching problems were found when analyzing the eye gazes and heat maps of the test persons as well, but generally it was shown that an eye tracking study is not always necessary to find the biggest problems which typical new users have with a software; just showing the tool

to inexperienced users and asking them what they think helps a lot to see potential problems. Developers and designers of software often do not have the knowledge of the workflow of the users, but make assumptions about it. Also software testers are often not unreserved with a new software version and do not find the same problems that test users in an eye tracking study make obvious.

The whole search engine was overhauled with the findings of the study. Besides that the results of the AttrakDiff surveys were gathered. According to the author's experience, six to ten test persons are generally adequate to show big statistic effects. For statistic effects of small or medium size a larger number of participants would be necessary, but those effects are mostly not the focus of eye tracking studies due to the effort which has to be put into it. In that regard it is obvious that studies made at an early development stage have the benefit of already adding usability practices to the development. The software is still flexible enough to be changed in a short period of time. Therefore it grants the creation of an optimal user-oriented product.

By including a usability study in the project, the user-friendliness of the developed website could be tested and improved within the project. The study enabled the project team to learn about optimization potentials. The involved developers estimated the effort to adapt the website according to the items identified by the study. Afterwards, the items were prioritized in order to use the remaining time as efficiently as possible to improve the usability.

IV. DISCUSSION

Especially for application-oriented projects, including thoughts on usability of the project results already in early phases of the project is a reasonable approach. Usability studies are a rather easy way to find out how to improve the user interface as hurdles are made visible and can be addressed before the release of the software. About 10% of a

software project's budget should be spent for usability issues [11]. This increases the learnability, efficiency and the user's satisfaction.

In the end, project results can become more widely spread and used if usability has been taken into account.

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Attribute-based data quality evaluation in regional Material Flow Analysis

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Abstract— A method for data quality evaluation in macro scale MFAs such as national resource budgets is presented. MFA data is never totally accurate but may have certain defects. The four information defects “semantic”, “representativeness”, “provenance” and “context” are introduced. These information defects are considered to be functions of data attributes. Data attributes are assigned to MFA data according to an existing framework. A method for quantification of information defects and for expressing the data quality of a flow by a single number is presented. It provides opportunities for understanding and evaluating resource budgets, their *a priori* information basis and their information content.

Keywords— Material Flow Analysis, data characterization, data quality, information defects

I. INTRODUCTION

The available information base is critical for the validity of a resource budget and can differ significantly among budgets, depending on the studied material and on the spatial or temporal system definition. A national resource budget is a macro-scale regional Material Flow Analysis (MFA) of a national economy within a defined time period, usually one calendar year. Resource budgets have been completed for different industrial materials and nutrients (e.g. [1-3]) and are of increasing interest for economic and political decision making. The quality of available data is perceived to decrease over the life time of materials. That is, from the system input side such as trade and industrial production via consumption sectors to the end-of-life waste management sector. MFA data are usually unstructured, cross-disciplinary, have different formats and qualities and come from heterogeneous sources, such as official trade statistics, lab measurements or expert judgement. Often, these are no frequently generated data sets but individual values.

II. APPROACH AND FORMALIZATION

Uncertainty in resource budgets is rather an epistemic than an aleatory phenomenon, i.e. a consequence of imperfect knowledge, and not a statistical problem of variability. This is because each material flow within a temporally and spatially defined system is not subject to variability, but could

potentially be exactly known, given perfect information. However, MFA data may be defectuous and are often of limited quality. For quantification of data quality, i.e. the *degree of belief* in given MFA data to be true, a semi-quantitative approach is proposed in this study.

Material flows are usually quantified by combinations of several elements of information, for example two information elements (such as amount of a good per time as mass/time and information on a concentration as mass/mass) or three information elements (such as quantity per time as number of pieces/time, a ratio as mass per piece and a concentration as mass per mass). The information quality of flows is evaluated respectively, i.e. in a hierarchical three-step procedure from data elements to information elements to flows (**Figure 1**).

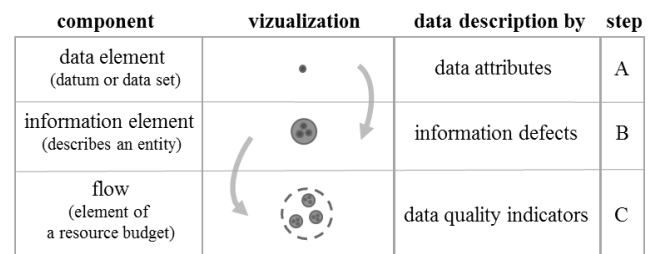


Figure 1: Scheme of data quality quantification: Data quality indicators are a function of information defects, which depend on data attributes.

A. Data attributes

Data attributes are data-associated annotations concerning semantics, logic, context, use, and origin of the data (such as the temporal and spatial adequacy, meaning, collection procedure, and producer). The systematic assignment of data attributes to data elements is facilitated by a data characterization matrix, which includes a full inventory of the quantitative information basis of a MFA study [4]. The approach in [4] can be applied for analyzing the structure of resource budget databases.

In **Table 1**, relevant data attributes are listed. Specifications of data attributes and a procedure for assignment of attributes to data is provided in [4].

Table 1: Data attributes [4] relevant for data quality evaluation.

data attribute	attr. no.
number of samples n	a104
semantic precision	a202
variety	a211
disparity	a212
producer type	a308
origination type	a311
origination quality	a312
temporal variability	a406
spatial variability	a408
variability by further relation	a410
temporal divergence	a411
spatial divergence	a412
further divergence	a413
adaptation type	a414
adaptation quality	a415

B. Information defects (ID 's)

Information defects [5] of individual pieces of information are quantified on an ordinal scale from 0 (no information defect) to 1 (maximum information defect). Information defects indicate the deviation of given information from a desired state of perfect knowledge. This is implemented by formalization of four information defects, that is, "semantic", "representativeness", "provenance" and "context" (ID_S , ID_R , ID_P , ID_C , see equations 1-4) as functions of relevant data attributes. The numbers in the equations (i.e. a212) refer to the attribute numbers provided in **Table 1**.

$$ID_S = a202 \quad (1)$$

$$ID_R = (\sqrt{a211} * \sqrt{a212})^{a104/(a104+1)} * \frac{(\sqrt{a211} * \sqrt{a212})}{\sqrt[3]{a104}} \quad (2)$$

$$ID_P = (((a311+a312)/2)^{1.5} + a308^{1.5})/2 \quad (3)$$

$$ID_C = y - a414 * (1 - a415) * y \quad (4a)$$

with

$$y = (\sqrt{a411} * \sqrt{a406} + \sqrt{a412} * \sqrt{a408} + \sqrt{a413} * \sqrt{a410})/3 \quad (4b)$$

Equations 1 to 4 are proposed for quantification of information defects. They are assumed within the concept and have been tested on historic MFA cases. They may be varied during the further concept development based on new insights.

The four information defects are aggregated to a total information defect ID_{tot} according to the Euclidian distance (equation 5). That implies that higher ID 's have more weight in ID_{tot} than low ID 's.

$$ID_{tot} = \sqrt{\frac{(ID_S^2 + ID_R^2 + ID_P^2 + ID_C^2)}{4}} \quad (5)$$

C. Data quality indicators (DQI)

Since material flows are usually quantified by combination of several information elements, the ID_{tot} 's of these information elements need to be aggregated for quantification of a DQI . For aggregation of several ID_{tot} 's, Equation 6 (inspired by Gaussian error propagation) is proposed.

$$DQI = \sqrt{\sum_{i=1}^n ID_{tot,i}^2} \quad (6)$$

DQI converges to 1 with increasing number of information elements that need to be combined for quantification of a flow. In the following, a data quality indicator of a material flow is calculated for illustration of the presented concept.

III. ILLUSTRATIVE EXAMPLE

The data quality indicator of a flow of the 2011 Austrian Pd budget [6] is calculated (Palladium (Pd) flow in end-of-life flatscreens, flow "F5"). Two information elements are combined for quantification of flow F5: number of EOL flat screens (information element F5.1) and the Pd content in discarded flat screens (information element F5.2).

A. Data attributes

The quantification of the four ID 's is illustrated for information element F5.2. The set of data attributes for characterization of F5.2 is provided in **Table 2**.

Table 2: Data attributes of information element F5.2 according to [4].

no.	attr. value	no.	attr. value	no.	attr. value
a104	1	a311	0.4	a411	0
a202	0.2	a312	0.4	a412	0
a211	0.5	a406	0.2	a413	0
a212	0.6	a408	0.2	a414	0
a308	0.3	a410	0.5	a415	0

B. Information defects

In **Table 3**, the information defects of F5.2 are presented. They are calculated based on **Table 2** according to the equations 1-4 and aggregated to ID_{tot} according to equation 5.

Table 3: Information defects of information element F5.2.

ID_S	ID_R	ID_P	ID_C	$ID_{tot,F5.2}$
0.20	0.41	0.21	0.00	0.25

ID_{tot} for information element F5.1 is quantified in the same way.

C. Data quality indicators

ID_{tot} of F5.1 and F5.2 are combined to a DQI of flow F5 according to equation 6 (see **Table 4**).

Table 4: Calculation of a DQI by combination of ID_{tot} 's.

$ID_{tot,F5.1}$	$ID_{tot,F5.2}$	DQI
0.22	0.25	0.33

The DQI of flow F5 is 0.33, where 0 denotes "optimal data quality" and 1 denotes "poorest data quality". The illustrated procedure can be applied for all flows of a resource budget to identify weaknesses within a budget and to compare different resource budgets to one another.

IV. DISCUSSION AND OUTLOOK

A definite, "true" evaluation of data quality is intricate. Still, it is possible to analyze data quality in resource budgets in a differentiated and systematic manner. This can be done with a model based on experience and on the best available knowledge, as in the model proposed in this study.

The introduced model requires resources, especially for assignment of data attributes. However, it can contribute significantly to the understanding of the information basis of a

study. Its main benefits are that (1) data quality is regarded as a complex, multi-dimensional problem, (2) it is based on a conclusive theoretical framework of information in MFA [4] and that (3) it is designed to minimize the subjective influence of agents.

In subsequent research, the model will be varied, tested and adapted. The procedure will then be implemented in a spread sheet tool to facilitate straight forward data quality evaluation in resource budgets. It can be employed for rigorous assignment of data uncertainties in regional Material Flow Analysis. The proposed procedure provides opportunities for understanding, evaluating and comparing resource budgets according to their information basis and their information content.

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Data reconciliation under fuzzy constraints applied to wood flows in Austria

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Abstract—Material flow analysis deals with gathering, harmonizing, and analyzing data about physical flows and stocks from different sources with varying quality in order to quantify the material turnover of a defined system. As data availability and quality is limited, there is uncertainty that the available data represent the actual value of interest. In the present study this degree of belief is expressed via fuzzy sets, which specify the possible range of values of the input data. The input data are forced to comply with the mass balance constraints given by the material flow model. As a result, possible ranges are calculated for each flow and consistency levels are determined to identify flows which are in good agreement with the model and flows which are hardly consistent. The method is illustrated using a sub-system of the Austrian wood flow model as a case study.

Keywords: Material flow analysis, Epistemic uncertainty, Uncertainty overdetermined, Possibility theory, Fuzzy sets, Wood budget

I. INTRODUCTION

Due to data limitations, material flow analysis (MFA) is confronted with uncertainties affecting the reliability of the results [3]. Using quantitative methods as a treatment for uncertainty by assuming that the flows within a system have specific density functions is typically not justified in situations of poor information [2]. Fuzzy set theory provides a framework to deal with scarce and imprecise input data arising rather from vagueness than due to randomness alone [1]. It enables to distinguish between the different types of data uncertainty in order to not confuse what is known with what is assumed. Membership functions are used to characterize the given information, allocating a certain positive "degree of belonging" to each value within the possible range of a flow belonging to the system. In this study a method for data reconciliation under fuzzy constraints is presented and applied to the wood flows in Austria in 2011 and in order to investigate the effect of different uncertainty characterization results, three different procedures to derive membership functions of flow input data are tested.

II. CASE STUDY ON AUSTRIAN WOOD FLOWS

Wood is a renewable resource with highly competing end-uses. Material uses of wood as construction materials, in furniture or in other products conserve the resource and therefore (potentially) enable another use of wood at the end

of the product lifetime, either via energy recovery or material recycling. However, the current understanding of wood flows in Austria does not allow for a reliable assessment of the resource efficiency of wood use. Therefore, it is an ideal resource for testing and using reconciliation procedures for fuzzy data to identify critical issues with respect to input data quality as well as wood management mechanisms. The major challenges for establishing the Austrian wood budget are, on the one hand, the data gaps in the life-cycle phases of wood processing and the management of waste wood flows, and on the other hand, the disparity of measures used for quantifying the amount of traded wood and wood-containing products. The

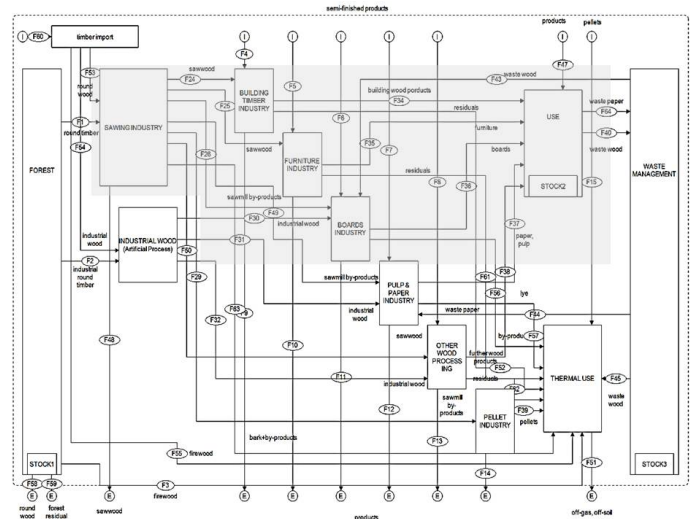


Fig. 1. Austrian wood balance system 2011 with highlighted observed sector.

focus of the case study is on a subsystem of the Austrian wood system (see Figure 1). In order to test the approach, we concentrate on 5 processes where wood is processed, namely the Sawing industry, the Boards industry, the Building timber and the Furniture industry as well as the Use-phase of wood products. All other related processes, which are linked to this system by flows, are defined to be outside of the system boundary and considered as import and export flows. There are no recycling loops considered in this subsystem. The major interest of the case study is in wood flows, historic stocks of wood are not investigated.

III. UNCERTAINTY CHARACTERIZATION & BALANCING OF MODEL AND DATA

As a result of the data reconciliation procedure, consistency levels are determined for each flow of the reconciled model, indicating the agreement between the given data and the mass balance constraints defined in the model. On this basis, the reliability of the data for a specific flow is evaluated relative to the other data used for the balances. Uncertainty characterization always remains subjective to some degree. Reconciled fuzzy ranges could be wrong even though flow data and balance constraints are in perfect agreement with high consistencies. Therefore, three different procedures to derive membership functions of the wood flows are tested. In the base case, information fusion is used to merge competing input data to a mutual function. In the second case, the uncertainty ranges associated with the original input data are reduced, to highlight the effect of lower estimates for basic uncertainty on data reconciliation and the resulting consistency levels. In the third case, a disjunctive approach constituted through intersections of membership functions is used to characterize the uncertainty of the wood flows. The effects of the modified procedures on the wood flows inserted in the model and on the results of the reconciliation process are evaluated, resulting in a trade-off between the credibility assigned to input data and the calculated consistency levels. Conclusions, which are drawn out of these computational tests, are used to get a better understanding of the Austrian wood balance model with respect to the reliability of underlying data and the sensitivity of relevant wood resource management flows.

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Potentials and Limits of Citizen Science to complete the Environmental Knowledge Base

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Extended Abstract—

I. INTRODUCTION

Governments on all levels request for better regulation, including increased transparency, accountability and coherent policy making, robust scientific support for impact assessments, stakeholder involvement, and the best use of scientific knowledge for new products and services. Within the EU, the need for more effective civic engagement is particularly reflected in the Better Regulation Package, following EC President Juncker's pre-election statement "either we succeed in bringing European citizens closer to Europe, or we fail".

Environment and sustainability related issues have an established position in this arena. On the European level, this especially includes the:

Aarhus Convention, in which the institutions and bodies of the European Union are requested to assist and provide guidance to the public with regard to access to information, participation in decision-making and access to justice in environmental matters;

INSPIRE Directive establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment;

Shared Environmental Information System (SEIS) that – amongst other things - aims to improve public access to environmental information and on the participation of the public in the collection and dissemination of environment information; and

Seventh Environmental Action Program (7th EAP), which guides European environment policy until 2020 and provides long-term directions of where it wants the Union to be by 2050.

In this wider context, this talk especially addresses the knowledge base for EU environment policy, with particular

focus on the interfaces and relationships between science and society. It outlines different modes to include citizen in the generation of scientific evidence, ranging:

From the re-use of citizen provided data – including passive contributions, for example, via mining social media platforms or even monitoring the use of mobile phones; as well as active contributions, for example, by using low-cost sensors to monitor environmental parameters or reporting the observation of certain animal species (activities also known as Citizen Sensing).

Via data analysis and quality assurance in peer-networks – either by Crowd Sourcing, for example, the analysis of the same data by many people followed by averaging of the results, as it is used in feature extraction from satellite or other remotely sensed imagery.

All the way to self-empowered Do-It-Yourself (DIY) science—where training material might be provided by research activities are automatically carried out by a community of practice; usually re-using open hardware and open software, for example, in balloon mapping.

The presentation should spark a discussion on new methods and tools for knowledge extraction, and the potentials and challenges of Citizen Science to complement traditional environmental monitoring, data collection, indicator development and assessments, as well as the communication of scientific results. Depending on the reactions of the audience, the debate might be expanded to also investigate the landscape of involved stakeholders, their expectations and responsibilities and potential roles in a potential future environmental knowledge base that might be shared between governments, academia, citizen and also industry. Eventually we might even succeed to close the loop of these opportunities and limits for indeed improving regulatory frameworks – within the EU, but also in its Member States and at sub-national levels.

Information Technology Continuance Research

A case study on changes in the usage of information systems for direct selling of bioenergy in agricultural businesses

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Abstract—The present study investigates the case of new information systems (IS) acceptance and IS continuance in the domain of agricultural biogas/bioenergy enterprises. The findings help to better understand how realignment processes promote or hinder the development of IS and IS user environments that facilitate knowledge transformation in the course of energy system transitions.

Keywords—information systems; acceptance; continuance research; agriculture; bioenergy

I. INTRODUCTION

The scope and functions of information systems (IS) applications are changing dynamically with the increasing professionalization and engagement of biogas enterprises in direct selling of electricity and heat. The use of IS in this domain ranges from the management of technical changes, managerial control functions and institutional core activities to the management of vendors and customers well beyond the enterprises itself. Lately, IS users in agricultural biogas enterprises have been confronted with substantial technical, economic and legal changes. These changes have contributed to misalignments in the IS use environments that need to be resolved for facilitating IS acceptance and continuance [1] and capitalizing on the potentials of IS use in this domain. Processes of realignment of IS use environments are yet not sufficiently well understood by scientist working in this domain. Augmenting the knowledge about realignment processes may help to increase the ability for managing such processes, and ultimately spur IS acceptance and continuance.

The present study embarks in an attempt to identify “best-practice” strategies and measures for dealing with misalignments in IS use environments based on lessons-learned from cases of agricultural biogas enterprises.

II. METHODOLOGY

The study applies an inductive approach for identifying common threads of IS development in selected cases of agricultural biogas enterprises in the State of Brandenburg, Germany. The results are based in primary information obtained from structured in-depth interviews and dialogues with the managers of biogas enterprises. The information was analyzed following a Grounded Theory Approach and using the Qualitative Content Analysis (QCA) methodology.

III. FINDINGS

The two IS changes focused on in this research are, 1) the implementation of remote control systems (RCS) and advisory service, and 2) the implementation of new IS applications for direct selling of electricity and heat. Both cases are related to the issue of IS integration, and the problems of intra- and inter-organizational integration of IS that are well described in the literature. The analysis revealed a variety of deliberation processes that were ignited by the outcomes, failed expectations and dissatisfactions with the IS use changes in the studied cases. These deliberations contributed to the construction of IS use rules and agreements, which are believed to have shaped the intention of the user to accept IS use changes. The results however indicate that not all deliberation processes produced outcomes which ensured IS acceptance and continuance, i.e. in these cases the alignment process had not been concluded successfully for different reasons.

The findings indicate that in most cases the IS users were able to respond proactively to the widening scope of IS use in biogas enterprises. The managers and plant operators of the studied enterprises seemed to be very much aware of the growing interdependences between the business activities, the rules and the procedures on the one hand, and the IS development on the other hand. The involved IS users were ready to accept institutional and organizational changes that were recognized as prerequisites for IS acceptance and IS continuance. This may be considered as an important capacity for coping with the widening scope of information systems, as changes in the IS often require changes in other spheres of the system like, like e.g. in the IS use environment.

IV. CONCLUSION

Finally, the results indicate that despite the many insufficiencies to be overcome in the domain of IS for biogas enterprises, the legal and economic stipulations within the prescribed energy systems transition in Germany offers a window of opportunity within which changes of IS may be spurred, and changes of IS use environments can be reached for improved IS usages.

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Tablets - Suitable Problem Solvers for Business Cases?

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Abstract—Tablets aren't a new idea. They were already described in the early science fictions like Isaac Asimov's novel *Foundation* from 1951 and are commercially available since 1989, e. g. the Grid GridPad 1910. Since Apple released the first iPad in 2010, tablets became favored and are in vogue today. Some experts already proclaim the end of the PC era. However, if tablets substitute PCs for private use, what are about the potential to suit the needs of organizations? In our contribution we consider this question and discuss, whether and in which way tablets are problem solvers. In summary, tablets are potential problem solvers but in which specific way depends on organization needs and business cases as well as the existing system landscape and social aspects.

Keywords—*Tablet; iPad; Problem solver; Business cases; iOS; Android; Windows 8*

I. INTRODUCTION

Due to numerous manufacturers sustainable decisions in IT investments aren't easy. Imagine you are IT manager and the old PCs of an administration department e. g. human resources, financial or controlling have to be replaced. Now you face the situation to decide which type of device, e. g. personal computers (PC), notebooks or tablets, is the best for administration purposes and should be bought. Since Apple released the first iPad in 2010, tablets became favored and are in vogue today. In fact the number of sold tablets in general increases year in and year out [1] and estimations of IDC proclaim that sales of PCs (Desktop-PCs and portable PCs) will decrease while the number of tablets will permanently increase until 2018 [2]. For private use, tablets offer a wide range of functions, functionality and apps, e. g. email clients, maps, as well as navigation systems, web browsers, and many more. Facing to this high user-friendly usability of tablets and adapted from decreasing sales of personal computers (PC), some experts already proclaim the end of the PC era [3]. The described development makes it hard to make sustainable decisions. The worst case is to buy devices not fitting the required needs. Such a decision would have negative impacts on the three pillars of sustainability in terms of sunk costs, disappointed employee as well as waste of resources. In order to avoid such decisions our contribution aims to answer the question "Tablets - Suitable Problem Solvers for Business Cases?".

However, if tablets substitute PCs for private use, what are about the potential to suit the needs of organizations? Is a tablet a problem solver for business cases? In our contribution we consider this question and discuss, whether and in which way tablets are problem solvers. We define the term "tablet" and identify which criteria are relevant for organizations to make purchase decisions. Furthermore, we explain how tablets and their Operating System (OS) fulfill these criteria. Last but not least, we summarize our contribution and present new covered gaps for future work.

II. TABLET

In order to discuss which type of device is the best for our business case, we have to clarify the differences between them. The term "personal computer" (PC) describes a large category of end-user devices, which are fulfilling the following criteria: they are digital computers with a largely automatic, and they are programmable by the user. The devices are accessible as a commercially manufactured product, a commercially available kit or in widely published kit plans. They are transportable by an average person, affordable by the average professional and simple enough to use that it requires no special training beyond an instruction manual. [4]

PCs can be divided in two subcategories. PCs with a more stationary purpose, like workstations, desktop computers, and home theater PCs and PCs with a more portable purpose, like laptops, notebooks, netbooks, and tablets. [5] What distinguish tablets from the other portable PCs?

Tablets in general aren't a new idea. They were already described in the early science fictions like Isaac Asimov's novel *Foundation* from 1951 and are commercially available since 1989, e. g. the Grid GridPad 1910 [6]. Over the time the understanding of a tablet has changed. Today, the terms "tablet", "tablet computer" and "tablet personal computer" are mostly used synonymously and most people have an idea what a tablet is and what it is good for, without to be able to give an admitted definition. We searched for a definition on websites of the top five tablet vendors, based on the shipped units in the fourth calendar quarter of 2014 [7], and found out, that only Amazon and Lenovo provide (their own) one.

Both definitions have in common that a tablet is a portable, light and thin touch screen device with data connectivity, e. g. 3G, 4G or Wi-Fi, which is primary made for tasks like

browsing the web, checking emails, watching movies, sharing photos and so on. Both vendors point out, that tablets with different OS are available and that each OS has its own proprietary app store, where users can download applications to extend the tablet's functionality [8, 9].

In addition, Lenovo describes that most tablets have no physical keyboard or mouse but the possibility to add an external one [9]. Amazon differs between slate tablets, with no physical keyboard or mouse, convertibles, laptops which can be transformed into a tablet, and hybrid tablets, tablets designed to work with keyboard docks [10].

In order to differ tablets from other end-user devices, e. g. laptops, smartphones, as well as ebook readers, we follow Lenovo's perception, which is compatible to Amazon's understanding of slate and hybrid tablets. However, we have to mention, that the borders between the end-user device categories are blurred.

III. PROMISES AND REALITY

Since the market launch of Apple's iPad in January 27, 2010, an increasing number of people use these devices. Besides the consumer market more and more vendors offer tablets for business purposes. Apple promises "[...] there's an iPad for every business. With iOS 7 and thousands of business apps, iPad transforms the way you work." [11]. Samsung states to help "[...] mobile professionals quickly and easily access critical business and personal information anywhere, anytime." [12] using the Galaxy Tab Pro line. Apart from this, Samsung promises user's work getting "[...] better, faster and smarter with the Samsung Galaxy Note® Pro [...]" [12]. Lenovo promotes its business tablet as well and claims it "[...] redefines business [...]" [13] as well as being a "[...] productive, mobile, reliable and secure device [...]" [13]. In spite of these promises one can also read headlines like "Tablets Not Good Enough for 'Real Work'" [14] or "Why tablets are hard to swallow for business" [15]. In conclusion there must be a gap between the promises the vendors made on the one hand and the user expectations on the other hand. Due to the variety of vendors and available tablet models on the market for organizations, it isn't easy to find the right one. The top five tablet vendors are Apple, Samsung, Amazon, Asus and Lenovo [7]. Table 1 shows the number of business tablets available at the vendor's websites separated by OS.

TABLE I. TOP FIVE TABLET VENDORS AND THEIR OS [16]; [17]; [18]; [19]; [20]

Vendor	iOS	Android	Windows ^a
Apple	22		
Samsung		47	1
Amazon ^b		17	
Asus ^b		23	3
Lenovo ^b		7	14

^a. Include all Versions of Windows 7, 8, and 8.1

^b. Due to the missing differentiation between business and consumer tablets on vendor website, the all in all number of available tablets is given.

IV. TABLETS - STATE OF THE ART

Organizations, which are interested in tablets for business purposes are facing an extensive range of products. Mostly, available OS and tablets depend on each other. The selection of an OS limits the number of available end-user devices and vice versa, e. g. iOS and Apple's iPad.

As already mentioned in section two, the functionality provided by tablets depend on their OS. Against this background we analyze iOS, Android, and Windows regarding criteria which are relevant for organization needs. In addition we also consider other aspects which could influence the business strategy of organizations like finance, environment, and target audience.

Table 2 characterizes the mentioned tablet OS regarding their first release date and producer as well as its current version and market share.

In the following, we refer to the current version of the OS, otherwise we will mention it. The same apply for Windows 8.1 RT and Pro.

TABLE II. CHARACTERISTICS OF TABLET OS [21]; [22]; [23]; [24]; [25]; [26]; [27]; [28]; [29]; [30]

OS	Producer	Market Share	First Version	Release Year	Current Version
iOS	Apple	27%	4	2010	8
Android	Google	66%	3.0	2011	5.0
Windows	Microsoft	7% ^c	7	2009	8.1

^c. Include all Versions of Windows 8 and 8.1

Next to the performance of built-in hardware components, the business suitability of tablets is influenced by their OS. Consequently we compare iOS, Android and Windows regarding to important business functionality. Due to missing information in literature about functionality mostly required by organizations, we clustered several business requirements into five categories. As shown in Table 3, these are: Apps, data exchange and access, security, strategic platform, integration and administration effort.

A. Apps

The category "apps" examine both the number of apps available in the specific store and solutions to install in-house apps. As well as for traditional software the make-or-buy decision applies for apps, too. If there is a large number of apps in a store the probability to find the right one for a specific task is much higher than in a store with a small number. Next to this, the ability for installing traditional application improves the situation to find suitable and existing solutions. Moreover a large number of commercial apps encourage competition among developer and increase the quality of apps. Microsoft's app store counts more than 202,000 tablet apps [31] whereas in Apple's app store are more than 725,000 apps available for Apple's tablet iPad [32]. Despite these in Google's play store are approximately 1,400,000 apps for android based devices [33]. With different effort all three OS allow to install in-house apps and those of third parties [34]; [35]; [36]. Beside the

opportunity to install apps, Windows Pro provides the option to install traditional application.

B. Data Access and Exchange

The category “data access and exchange” describes how users can access data on their tablets and how they can exchange this data with other people. For business purpose it is important to know this fact, because of the security and availability of business data, e.g. right of access, backup, central data management.

On iOS each app decides where the data will be stored, whether internal or external in the cloud. The access and exchange of internal stored data is possible with additional apps only. Android and Windows have built-in file browsers to access the data and allow exchanging the data in different ways, e.g. USB or network.

C. Security

Next category we examine is “security”. Due to the content and importance a large amount of business data are not intended for public consideration. Especially high sensitive data should be accessible for authorized persons only. Against this background privacy and security are important criteria organizations should know about to choose the right tablet. A detailed comparison of iOS 7, Android 4.3 and Windows 8.1 regarding eight security aspects are given in a whitepaper of Experton Group AG [37]. To summarize this whitepaper, iOS’ security strengths are encryption and apple updates, on average are access protection as well as the protection against malware. Weaknesses are missing functions and features, e. g. separation of private and business data but also allocation and separation of private and business apps. Further weaknesses are missing remote data removal functions and no multi-user-support. Androids security advantages are a multi-user-support, separation of private and business apps. On average is the access protection. Androids security weaknesses are missing functions and features, e. g. remote data removal functions, encryption, updates for the OS, separation of private and business data but also the protection against malware. Unlike iOS and Android, Windows fulfill these criteria in a good way [37].

D. Strategic Platform

The category “strategic platform” represents which software vendors produce apps or application for the selected OS. Most organizations already have a software landscape based on different applications. Tablets have to be integrated in this landscape and their OS should be supported by the application vendors.

In order to give an impression for this category we search on the app stores of Microsoft, Apple and Google for apps of the top three vendors in “Software & Programming” of Forbes Global 2000 list 2013 [38]: Microsoft, Oracle and SAP. Microsoft supports Apple’s iOS and Google’s Android with apps like Office, OneDrive, Lync and SharePoint. For Windows, Microsoft offers additional apps, e.g. Maps, Power BI, and ships Office 2013 RT with Windows RT for free. Oracle provides apps for iOS and Android, e.g. Virtual Desktop, Tap, Business Intelligence, CRM on Demand, but not for Windows. SAP offers a lot of apps for Apple’s iOS and

Google’s Android, e. g. SAP BusinessOne, SAP BusinessByDesign, and some of these apps for Windows. However, all current versions of Microsoft’s, Oracle’s and SAP’s desktop applications run on Windows Pro.

E. Integration and Administration Effort

The category “integration and administration effort” covers the needs of organizations to integrate tablets into their system landscape. In order to realize an integration of tablets with suitable cost, OS should have the required configuration options and OS vendors should provide administrative tools for this purpose. From user perspective, the OS should be user-friendly with just a few coherent configuration options for customizing. Regarding to this gap and the existing system landscape of organization, the effort to integrate and administrate tablets can be very expensive, e. g. separate device management [39].

All OS allow a basic integration into the system landscapes of organizations, e. g. to build intranet connections via VPN or to setup and synchronize to different email servers. In addition, Apple’s iOS offers some useful options for integration, e. g. VPN per app, enterprise single sign on or mobile device management [40]. Google’s Android provides a device administration API, which enables administration features at the system level [41]. Microsoft Windows RT doesn’t offer special tools for integration. In contrast, Microsoft Windows Pro can be fully integrated into a Microsoft system landscape, e. g. connect to an active domain controller [42].

F. Price and Environmental Aspects

Next to functional requirements the selection of a tablet model depends on the money. Each of the five top tablet vendor offer both low and high priced devices. Based on information, given at the US vendor’s websites, Table 4 shows the price for the cheapest but also for the most expensive tablet of the considered vendor. The price spread for tablets reaches from \$99.00 for Amazon’s “Fire HD 6 Tablet” [43] up to \$2,869.00 for the Lenovo’s “ThinkPad Helix” [44]. In case of replacing an old notebook or desktop computer a tablet as working tool could be a worthwhile option. But respecting the mentioned price spread, a wrong purchase decision costs up to \$2,770.99 per device if the low priced model meets all desired business needs as well. On the one hand the acquisition of apps and desktop applications can lead to further costs, but on the other hand working with tablet can substitute devices e. g. laptops, desktops, thin clients as well as these devices can reduce printing cost.

TABLE III. BUSINESS REQUIREMENTS AND THEIR FULFILLMENT BY TABLET OS

Apple's iOS smartphone and tablet OS	Google's Android smartphone and tablet OS	Microsoft's Windows RT tablet OS	Microsoft's Windows Pro tablet and PC OS
<i>Apps</i>			
725,000	1,400,000	202,000	202,000
<i>Data Exchange and Access</i>			
Data Exchange: <ul style="list-style-type: none"> cloud app 	Data Exchange: <ul style="list-style-type: none"> cloud app USB wireless connection memory card Data Access: <ul style="list-style-type: none"> file browser 	Data Exchange: <ul style="list-style-type: none"> cloud app USB wireless connection memory card Data Access: <ul style="list-style-type: none"> file browser 	Data Exchange: <ul style="list-style-type: none"> cloud app USB wireless connection memory card Data Access: <ul style="list-style-type: none"> file browser
<i>Security</i>			
Positive: <ul style="list-style-type: none"> encryption updates On average: <ul style="list-style-type: none"> access protection malware protection 	Positive: <ul style="list-style-type: none"> multi-user-support app separation and allocation On average: <ul style="list-style-type: none"> access protection 	Positive: <ul style="list-style-type: none"> multi-user-support app separation and allocation access protection remote data removal encryption updates data separation malware protection 	Positive: <ul style="list-style-type: none"> multi-user-support app separation and allocation access protection remote data removal encryption updates data separation malware protection
<i>Strategic Platform</i>			
Apps: <ul style="list-style-type: none"> Microsoft Oracle SAP 	Apps: <ul style="list-style-type: none"> Microsoft Oracle SAP 	Apps: <ul style="list-style-type: none"> Microsoft [+ Office 2013 RT] SAP 	Apps: <ul style="list-style-type: none"> Microsoft SAP Desktop applications: <ul style="list-style-type: none"> Microsoft Oracle SAP
<i>Integration and Administration Effort</i>			
Basic integration e. g.: <ul style="list-style-type: none"> VPN Email & Calendar Contacts Additional, e. g.: <ul style="list-style-type: none"> device management 	Basic integration e. g.: <ul style="list-style-type: none"> VPN Email & Calendar Contacts Additional, e. g.: <ul style="list-style-type: none"> administration API 	Basic integration e. g.: <ul style="list-style-type: none"> VPN Email & Calendar Contacts 	Basic integration e. g.: <ul style="list-style-type: none"> VPN Email & Calendar Contacts Additional, e. g.: <ul style="list-style-type: none"> Active Directory

But money is not everything. Especially those organizations which feel responsible for environment should concern about aspects like energy consumption, material efficiency or harmful substances as well. But it isn't as easy as it seems. There are two main problems, too many eco and energy labels as well as hardly comparable product eco declaration (PED) if these are provided by the vendors. In the third column Table 4 shows the way vendors provide product eco declaration.

TABLE IV. PRICE SPREAD AND AVAILABILITY OF PED [16]; [45]; [20]; [46]; [19]

Vendor	Price Spread of tablet models on vendors website [in US \$]	PED
Apple	249.00 – 829.00 ^d	on website
Samsung	119.99 – 749.99 ^d	on request
Amazon	99.00 – 579.00	not provided
Asus	no prices are given	no answer
Lenovo	109.99 – 2869.99	on website

^d. For some tablets n prices can be found on the mentioned website.

Beside other criteria, the aspect of target audience is very important for the right purchase choice of tablets in organizations. It strongly depends on the needs and functions of employees, which should get tablets for their work. Regarding to the work tasks and the linked computer usage of the employees, tablets can be problem solvers. For example, MURPHY mentions nine business areas where tablets can be good in, e. g. warehouse, high-end sales and retail sales, operation and service staff [47].

V. DISCUSSION

In order to manage the complexity and scope of our contribution we made constraints consciously. At first, we defined the term “tablet”. This definition excludes similar end-user devices, e. g. convertibles, laptops and smartphones. However, it is to mention that the border between these devices is fuzzy. At second, we focused on top five tablet vendors only. This decision determines other aspects like considered OS as well as done researches. Concentrating on highly comparable results we decide to look at specific versions of OS. That means, we exclude Microsoft's Windows Standard but also customized OS versions, e. g. Google's Fire OS. Due to the lack of already admitted criteria for tablet selection, we present our own one. These were identified by available information of the chosen vendors in conjunction with mentioned business key points of OS emphasized by their developers. Beside this, further aspects, e. g. hardware requirements, sustainability, and marketing strategies, could be taken in consideration. At last, our findings result on investigations. Nevertheless, we point out that our concept isn't proofed empirically, yet.

VI. CONCLUSION AND FURTHER WORK

Our contribution aimed to answer the question whether and in which way tablets are problem solvers for business cases. In summary, the first part of this question can be answered in a positive way. Owing to covered dependencies answering the second part of this question isn't easy. Influencing factors are

the specific business case, the existing system landscape as well as social aspects. All in all tablets can be powerful problem solvers, if organizations are able to find both the right tablet and a suitable setup.

The proof of concept regarding to real business cases is left to further work. Also the finding of additional business relevant criteria could improve the mentioned concept, in future.

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Using the OGC SOS Interface for Reporting Ambient Air Quality Data

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Abstract—This contribution describes experiences gained with the practical application of the OGC Sensor Observation Service (SOS) standard for reporting air quality information of member states to the European Environment Agency (EEA). It is not only shown how the member states are enabled to fulfil environmental reporting obligations but it is also explained how the EEA is able to benefit from the use of the SOS interface.

Keywords—*Sensor Web; OGC, Sensor Observation Service; air quality; e-Reporting*

I. EXTENDED ABSTRACT

Over the past years, significant efforts to collect observation data about ambient air quality in Europe have been expended [1], [2]. National air quality measurements have been set-up across the EU since the 1990's and European policies requiring the exchange of the measured data have been established, since a recent revision of the Implementing Provisions for Reporting [3] this also includes “primary up-to-date assessment data”. These Implementing Provisions also explicitly refer to a “standardised machine-readable form in line with the requirements of Directive 2007/2/EC” (INSPIRE) [4], hence implicitly mentioning using (Web) services for data transmission. In this context, the European Environment

Agency has the task to collect, assess and integrate the measured data of the different member states.

To perform this data collection across political and organizational borders, interoperability is a key factor to reduce the efforts necessary during data integration. For this purpose, a specific data model and encoding - a profile of the ISO/OGC Observations and Measurements (O&M) 2.0 standard - was developed. This data specification is mandatory for all member states when delivering air quality data to the EEA.

However, to ensure the full benefits of interoperability, not only the data model/format but also the way, how this data can be accessed, is important. Although there are no legally binding requirements regarding the specific data access interface, several member states (Belgium, The Netherlands, Sweden and the United Kingdom) as well as the EEA have decided to implement the OGC Sensor Observation Service (SOS) 2.0 interface [5] as a way to exchange and publish the measured air quality data.

The member states are not only intending to use the SOS interface - in this case the open source stand-alone SOS implementation of 52°North - to make their data available for harvesting by the EEA. There are also on-going activities to

also be applied in their infrastructures. Thus, there is a good chance that further SOS implementations serving air quality measurements will become available soon.

In summary, this article shows how environment agencies may benefit from the OGC SOS interface. This comprises not only a convenient way to fulfil reporting obligations for environmental data but also a good opportunity to enable the use of collected measurement data to build applications for informing the public or to offer scientists a convenient way to work with and analyse the data coming from multiple sources.

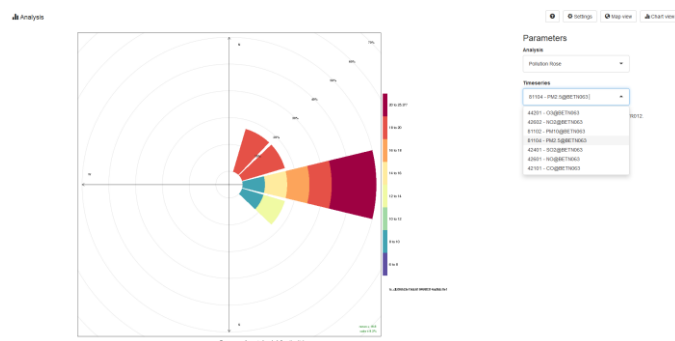


Fig. 1. Pollution rose plot of PM_{2.5} data measured by a Belgian station

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Currently, the data of several member states is already available through the SOS interface while further member states are currently investigating how this technology could

Vu Gia Thu Bon RBIS

An information system for environmental data in central Vietnam

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Abstract - Sustainable land and resource management is gaining more and more attention. Therefore strategies should be developed to deal with related problems such as climate change or land use changes. A lot of research in this field is going on and often many different disciplines are involved. In order to store, describe, analyze and disseminate their data, integrated data management systems are needed. One of these kinds of systems has been set up as the Vu Gia Thu Bon RBIS within the research project LUCCi (Land Use and Climate Change interactions in central Vietnam; founded by BMBF 2011-2015; <http://www.lucci-vietnam.info/>) as a project database and information system to support scientists and scientific workflows within the project. It also serves as an information and dissemination platform containing project results and collected base data for local stakeholders and other scientists. The Vu Gia Thu Bon RBIS (<http://leutra.geogr.uni-jena.de/vgtbRBIS/>) is built on the modular structured software platform RBIS (River Basin Information System). RBIS has been applied in several research projects worldwide (e.g. OBIS – Okavango Basin Information System [1] Centro-Norte-Chile RBIS, Jakarta RBIS [2] or Oti RBIS (Togo) [3]. The system is web based, has full read/write access, a fine grained user and permission management, is built on open source software and has a strong focus on the management of metadata together with the data itself and spatial relation. Additional functions are provided such as for handling time series data (e.g. rule based gap filling toolbox, direct access from modeling tools), and searching metadata datasets via CSW from other applications. RBIS also has multilingualism support (currently English, Vietnamese, Spanish, Portuguese and German) to reach a wider range of users [4].

One of the recent developments deals with the provenance of stored datasets. To describe in- and output data (e.g. for complex physically based environmental models) can be quite challenging, as you have to link and describe different types of data sources (e.g. time series data, geodata, soil samples, simulated data). These data sources are stored in RBIS or not, with a different level of available details and has been passed several processing steps using different tools (e.g. global climate model, hydrological model on basin scale, data extraction, unit conversion and aggregation functions). Elements of the ISO 19115-1/2 [5][6] standard were used and extended to describe lineage information within RBIS. The MetaViz [7] tool for the visualization of metadata and lineage information provided by GLUES (scientific coordination project for all regional projects within the same funding measure as LUCCi) was tested. The information was encoded with the ISO 19115 compliant XML format

and transferred using a CSW service. Via CSW only datasets and information are exposed, which are readable for a normal guest account.

We will show the Vu Gia Thu Bon RBIS as example of the underlying software RBIS and the current state of implementation using the lineage component of ISO 19115-1/2 as base to store provenance data within the system for several data types and to provide ISO compliant lineage information for other applications e.g. using CSW.

Keywords - *Environmental information system, time series data, ISO 19115, lineage information, CSW*

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A Green approach to save energy consumed by software

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Abstract— The availability of various services (i.e. eBank, eHospital) through the cloud has facilitated daily lives. It allows to make energy and money savings by preventing people from moving to accomplish a small task (for instance see his account at the bank). Furthermore, the availability of these services through mobile devices and their widely usage has a positive impact on energy saving. It is also worthwhile to consider technology addicts developing/using applications or software when estimating the growing impact of software on energy consumption.

The emission of greenhouse gases is being reduced thanks to technological progress. However, the increasing number of applications' users causes additional consumption. Therefore, in order to get a better efficiency, developers needs to be guided to optimize their development to establish *green* software.

In this poster, we've made a state of the art for these research questions by summarizing related works in this field and then we compare them.

We aim at establishing an estimation model for the consumed energy. We then investigate its performance and accuracy on a development project. The model will be used as an energy consumption measurement tool that guides developers building greener software.

The contribution to power measurement literature will continue by bringing improvement to the estimation of the consumption of other components; such as memory, disk and network, which are neglected in related models in literature. It

will allow us to have a higher accuracy in estimating the energy consumption of a program.

Using Java agents, the methods will be re-implemented automatically in order to observe their energy consumption. We will seek to be more precise in locating the most intensive pieces of code in each function to help developers optimize their codes.

The similar energy estimation tools in literature are analyzed in the paper. The research area of *green software* development is relatively new, and major part of the tools only provides with an estimation of the energy consumption of an application without involving the source code. Moreover, the recent tools, which have began to take into account the source code, do not take into account all the components that consume energy and / or request to integrate the code manually. Hence, there is a lack of precision and a difficulty of using these tools.

After this state of the art, an energy consumption estimation tool is proposed. It has been implemented so as to measure only the consumption due to the CPU, but it may be used for other components quickly and easily, in a near future.

The proposed tool is expected to be improved, and it is planned to dynamically identifying the locations of the head of the largest energy consumer code. This will allow developers to optimize their own codes to obtain *greener software*.

Keywords— *Green Software, Green IT, Sustainable Software, Energy Efficiency.*

A living lab campus: A unique opportunity to not be a “smart city”.

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Abstract—A unique opportunity lies in the hands of the resource managers and sustainability officers of campus universities. These campuses give opportunities for retrofitting technologies (e.g. wind turbines, solar PV panels), IoT sensing and actuation (e.g. electricity monitoring, HVAC controlling), and large-scale data collection of real time smart campus data (e.g. electricity generation and consumption, thousands of sensors worth of data). In many ways, these campuses are not dissimilar from smart cities, but they are of a much smaller and more manageable scale. As microcosms of cities, where people live, work and study, much of the population is also at an interesting and significant transition point in their lives—where in many cases they cease to be under the protective care of their parents who provide food and energy for them, and have to start engage with supporting themselves, and crystallising the behaviours, practices, thinking and obligations that will carry them forward as productive, or possibly, sustainable members of society. This poster proposes a new discussion surrounding ‘living-lab and ‘smart’ university campuses, and how such an initiative should be guided and shaped by sustainable ICT.

I. POSTER PROPOSAL

This sounds like the usual rhetorical ‘resource man’ [1] centric motivation that has encouraged the research and development of smart homes, smart cities and smart meters. But, firstly, beyond optimisation within an infrastructure, can such a resource become a living lab for encouraging more sustainable practices? How might we reshape the socio-technical complex to encourage and promote more sustainable ways of living? Smart cities and smart homes operate under the assumption that more data and more modelling will lead to more sustainability. Secondly, rarely do these projects consider the environmental impact of their deployments, focusing primarily on savings of money and fossil fuels. Even less often do these projects consider the energy and emissions impacts arising through large scale data collection (e.g. the impact of the sensors and network infrastructures), storage (e.g. the impact of storage large amounts of data), and processing (e.g. the energy required to model and process live data).

The benefits of sensing, actuation, prediction, and modelling of energy on a campus scale have the potential to reduce hundreds (if not thousands) of tons of CO₂ per annum, saving hundreds of thousands GBP on energy bills, and providing a large data set and platform for experimentation that can be utilised for both research and teaching.

We believe that campus wide sustainability projects should be at least as concerned about CO₂ reduction through changes in practices as they are about saving money through reductions in energy consumption (and the associated costs of such systems).

With that in mind, this poster is proposed as a springboard for discussion of the directions that a smart campus should take. In our opinion, a smarter campus should be about making the community of employees, students and all campus stakeholders ‘sustainably smarter’ people, and not just about big data and automation being utilised to save on energy bills. Affecting and sustaining changes on the campus and of the stakeholders and people should be the primary goal of any ‘living-lab’ or ‘smart’ campus vision.

With sustainability on a campus scale posing some unique research, ethical and sustainability challenges we ask the audience to participate in an open discussion of both exciting potential avenues of new research alongside the risks and barriers. For example, how can thousands of rent paying individuals become motivated to participate in more sustainable lifestyles? The people that work and live on campus expect certain levels of services and infrastructures that might not be deemed as sustainable.

This poster is proposing four main questions of this approach: 1) how can a living lab campus be leveraged to support campus wide changes in practice (e.g. not just individuals, but departments, businesses, and stake-holders alike), 2) what are the unique opportunities and problems for researchers that can be foreseen in a the vision of a living lab campus, 3) what new and radical trials and changes does a campus environment enable over that of a smart city or smart home? 4) what are moral and ethical bounds on sustainable ICT in reshaping practice, for example by changing the expectations around access to resources such as energy, thermal comfort and so on, where people live and work.

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An operation and business model to exchange and open environmental data

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ABSTRACT

Data has been referred to as the new raw material of the 21st century. However, it is currently very difficult to share environmental data since the information typically resides on geographically disparate and heterogeneous databases (systems). We proposed an operation and business model, as shown in Figure 1, which comprised with two groups of organizations working together based on the principle of partnership.

Data suppliers: (public sector) organizations they publish their data via the open interface and standard to allow others to use and reuse it. These organizations are government agencies responsible for collecting and generating data on environmental issues such as the Taiwan Environmental Protection Administration (TEPA), Water Resources Administration, Forestry Services, and some other agencies.

Data users: (private sector) organizations they aggregate published data to develop and design software applications for business and individual consumption. In addition, there are also organizations utilize published data to enhance their existing products and services.

Public-private partnership: government cannot be expected to do everything. In cooperating with the private sector as a partner can make sense based on the principle of partnership and appropriate process. The public sector continues to focus on performing services that are essential. Private sector is able to provide products and services on top of the open data made available for exploitation. Therefore, the partnership can be fulfilled through planned processes and interfaces.

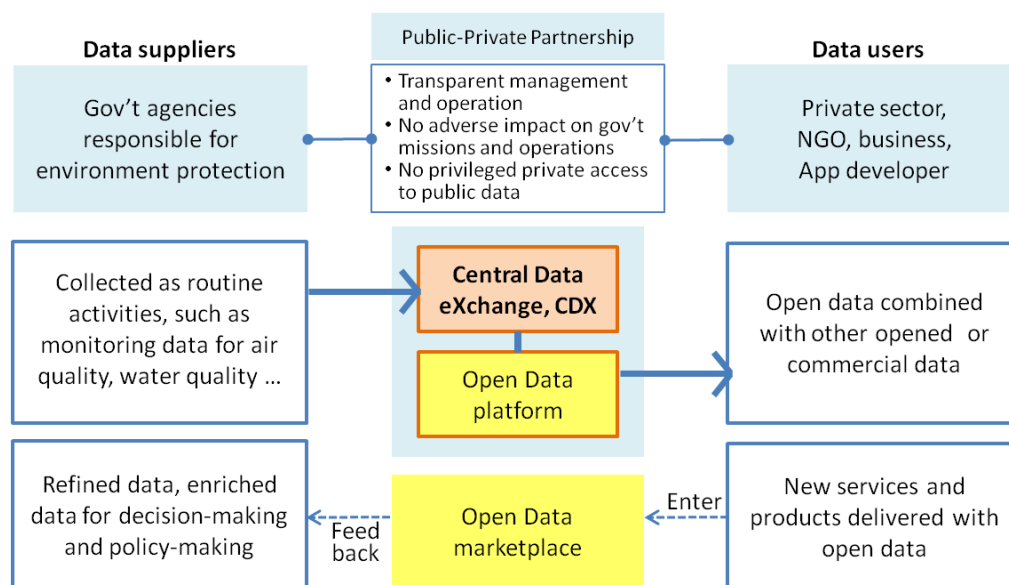


Figure 1: The operation and business model

Central Data eXchange (CDX)

The Central Data eXchange (CDX) which provides a publish-subscribe solution for effective information delivery among these agencies. CDX enables TEPA and participating agencies to work with stakeholders - including local governments - to enable streamlined, electronic submission of data via the Internet. CDX also provides the capability for submitters to access their data through the use of web services.

Data that exchange through a publish-subscribe approach requires the senders to publish data without explicitly specifying recipients or having knowledge of intended recipients. Similarly, receivers must receive only those data that the subscriber has registered an interest in. Figure 2 illustrates the publish and subscribe functionality of CDX. It provides participants with the ability to:

- Submit and receive data through one centralized point, in a variety of formats including Webs Forms, XML, or flat-file.
- Utilize publishing services to share information collected by other stakeholders and exchange data with target systems using web services.

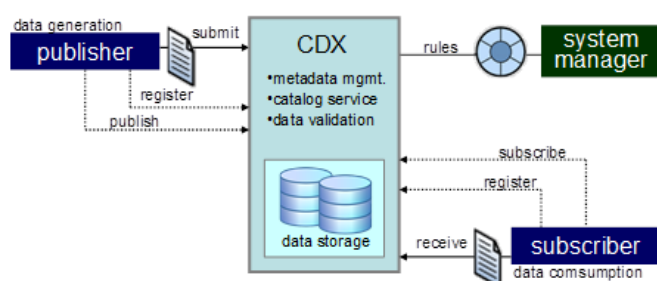


Figure 2: The publish and subscribe functionality of CDX

Open data platform

TEPA views environmental data as a strategic asset to protect our environment. For bring tangible benefits to public, we are on track to fulfill the requirement of the open data policy proposed by Executive Yuan, Taiwan's central government in 2013.

There are currently over 150 datasets on the open data platform including hourly air quality monitoring data, UVI values, water monitoring data, etc. The datasets are in various formats such as JSON, XML, SHP, and KML for spatial data. We have taken a number of measures to encourage use of the datasets already published. For ensuring the data quality, we also establish a working group to oversee and provide input to the open data efforts.

One of the basic ideas behind making government data “open” is to allow the public and entrepreneurs to use and combine public data with other data in new and useful ways. We will propose a business model to develop a partnership between public and private sectors. TEPA has put a lot of thought into the identification of high value data sets and the roles and rules under these datasets will be made available to private sector “partners” for recombination with other resources. When public and private data are combined some interesting intellectual property, ownership, and pricing questions will be raised. In addition, there are some other issues need to be address such as using same dataset but with different interpretation shown in Figure 3.

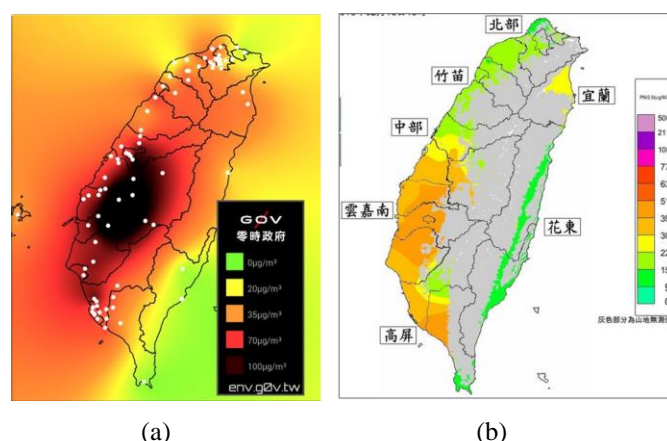


Figure 3: Using same dataset of hourly air quality monitoring data, but with difference interpretation. (a) was made by a NGO (<http://env.gov.tw>) and (b) was made by TEPA (<http://taqm.epa.gov.tw/taqm/tw/ContourMap.aspx>). Does this cause adverse impact on government mission?

Keywords—Environmental Data; Data Exchange; Open Data

Civic Capacity and Sustainability in a Chinese City

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With a few exceptions [1]–[9], most sustainable human-computer interaction (HCI) work focuses on the implementation of novel systems or empirical studies in developed Western countries. Research on non-Western world is both necessary and can expand understandings of sustainable HCI. We report an ethnographic study of the efforts of an environmental volunteer organization, the Environmental Guardian Group, to promote sustainability in a Chinese city. Our research considers how group-level civic capacity can promote effective sustainability-related civic engagement. We use the term civic capacity to mean communities’ “ability to mobilize their members (both individual and institutional) into collective action aimed at improving their circumstances” [10]. Civic capacity can be realized at the level of associations, neighborhoods, cities, or nations [10]. Available resources, as well as local institutions and culture [11], determine collective civic capacity [10].

The ethnographic study lasted from August, 2014 to September, 2014. The methods included participant observation, two focus groups composed of both governmental officials and ordinary citizens, and sixteen semi-structured interviews with volunteers in the group.

We found that the group’s civic capacity was hindered by their own lack of expertise, by lack of public trust in civic organizations, and by the interventions of the local government. The Environmental Guardian Group struggled with their members’ lack of expertise, which limited their ability to work toward their goals. Most members were low-income migrant workers with a middle or high school education. Few possessed the essential know-how the Group needed in environmental protection, management, and public relations. Lack of funds, experts, and training opportunities created a poor learning environment in which the group could not bootstrap its knowledge and skills. Therefore, members focused on mundane activities such as recycling batteries and weeding community gardens. As we saw, these humble activities in turn discouraged more expert citizens from joining.

Like many Chinese social organizations [12], the Environmental Guardian Group depended on local government funding. Although government funding and permits enabled the Group’s civic activities, these interventions also came with government supervision. For instance, government officials required that the Group submit activity proposals and seek approval before acting. Sometimes the government directly commanded a group action. With so

much time and energy spent seeking government approval and heeding government commands, the Group’s civic capacity was severely constrained. Pragmatic needs dictated that they maintain non-confrontational relations with the government, which meant that group officers usually made the choice to compromise in the face of governmental commands.

Information and communication technologies (ICTs) fail to empower the group facing the challenging situation. Group leaders hoped that ICTs could help facilitate communication with the government and the public, and ultimately increase their civic capacity. However, their lack of public relations skills limited the production of influential publicity. They regularly posted information such as events calendars and photographs, creating thousands of Weibo posts. But most of the posts did not get a single re-post or comment. In addition to the challenge of promoting themselves, the Group considered Weibo a double-edged sword. It could be tricky to use, and even dangerous, if citizens misinterpreted the Group’s actions due to the general distrust of civic organizations following the Red Cross incident [13], [14]. Previous research published before 2011 demonstrates that many organizations in China established credibility and trustworthiness in the public eye by displaying their numerous government ties [12], [15]. However, after the Red Cross scandal, public trust declined. The Group found that ICTs did not support communication with the government very well. The government had provided the Group with relevant officials’ email addresses and the e-government website where citizens could submit suggestions and feedback online. However, the Group rarely used them, because computer – mediated communication can easily sound “too formal, unfriendly, and disrespectful,” according to a group leader. The leaders found face-to-face communication more effective.

Our findings show that lack of expertise and government intervention constrained the Environmental Guardian Group’s civic capacity and hence their effectiveness. ICTs’ had limited potential to overcome a complex set of regulations, cultural norms, and social problems such as low levels of education. Future work in the Chinese context must take account of voluntary organizations’ relationship to government, i.e., that in China, legal organizations are always linked to government. For ICTs to contribute to building civic capacity, the government must be a stakeholder. Designers need to consider how to design for systems facilitating negotiation between government and voluntary organizations.

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Classification of consumption data for energy management with Smart Metering

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Abstract—As part of a software project with of the Solar Computing Lab at University of Applied Sciences Bielefeld, a software solution was developed which allows users to classify and enhance their power consumption profile. In addition, the software should be able to give the users useful advices on their consumption and eventual alignment of their solar system.

I. PURPOSE

Since energy gets more and more expensive, there is no more time to waste and start saving energy. For achieving this goal it is necessary to wake peoples awareness of their consumption behaviour. The spreading smart metering technology gives us the opportunity to utilize the data measured for this purpose. With the application we developed, we want to give an opportunity to the end consumer to learn about their own consumption behaviour and to improve it. In addition the combination of electricity production forecasts and typical consumption profiles give us the possibility to reduce the loss of profits, e.g. energy storage system with intelligent delayed loading algorithm based on the consumption profiles [1].

II. APPROACH

The base of the project consists of smart metering from different sources. For classification smart meter measured data of the Institut fr ZukunftsEnergieSysteme (IZES; <http://www.izes.de>) were used. These data consists of 289 sets of households and their consumption data which were collected over a longer period by various public utilities. In addition, the respondents from the participating households were interviewed. As a result, supplementary information, such as the composition and size of the households as well as the job situation of the participants were available for further analyses.

Furthermore there were consumption profiles from the online platform Volkszhler.org (<http://www.volkszaehler.org>) available. Depending on the quality of the data, these profiles are intended to serve as a basis for the functional testing of the application. To identify defective data sets in the IZES consumption data pool different kinds of filter algorithms were developed. First, a filter, that examines whether the consumption value changes in a specified period by a defined percentage, was implemented to identify faulty measure points that were filled up with the last measured value. Another implemented filter checks if the consumption values deceed or exceed the boundaries of a normal households consumption over a longer period of time. Days that hold a number of

defective values around 30% were mark as bad days. For the further process only households, whose number of bad days was less than 50% of the total number of measured days, were used (Figure 1).

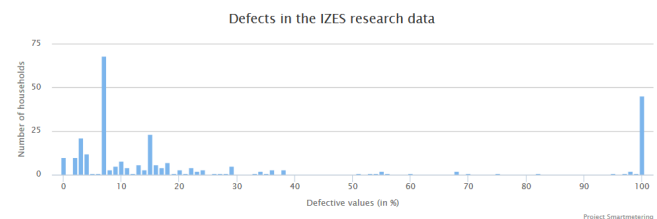


Fig. 1. Percentage of defective values with the correlating number of households

After filtering and preprocessing, clusters were computed [2] out of the IZES data in order to group those with similar consumption behaviour. For this step the software KNIME (<http://www.knime.org>) was used. The IZES data were first divided into summer, winter and the transition seasons spring and autumn. Then, each of these groups was sorted according to business days, Saturdays and Sundays (Figure 2). For each of these divisions separate clustering processes were carried out.

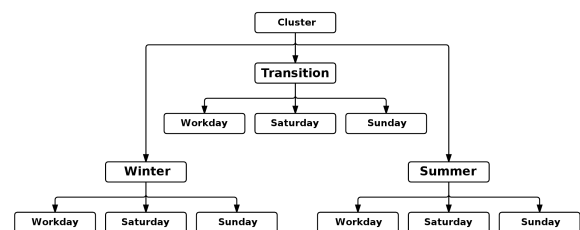


Fig. 2. Splitting of the data for the clustering process

To find the optimal number of clusters was a grave step. If it was too high the result would be multiple analogue clusters and a clear assignment of a consumption curve to a specific cluster would be no longer possible. Otherwise there would be a loss of information with a too small number of clusters. After various attempts the actual count of clusters was set to 16. In Figure 3 the results for the workdays in summer are seen.

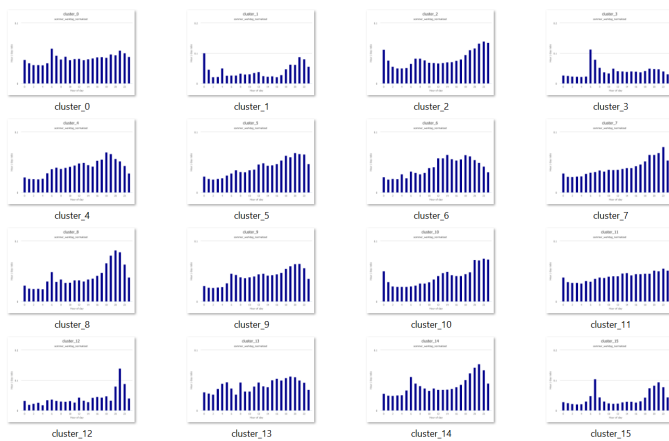


Fig. 3. Cluster overview

If a user wants to have his consumption curve classified, the system using the least-square algorithm [3] to identify one of the 16 clusters that matches best with the users consumption curve (Figure 4). As seen in the graphic, the value got normalized on the daily overall consumption for a better comparability. Depending on his daily consumption behaviour and the assigned cluster, the application is able to advise the user about the optimal orientation of his PV system. An example would be if the main consumption occurs in the morning and evening the user is advised to install a PV system in east-west orientation. For the future it is planned to enlarge the number of advices, e.g. usage of electric devices depending on the temporal electricity price.

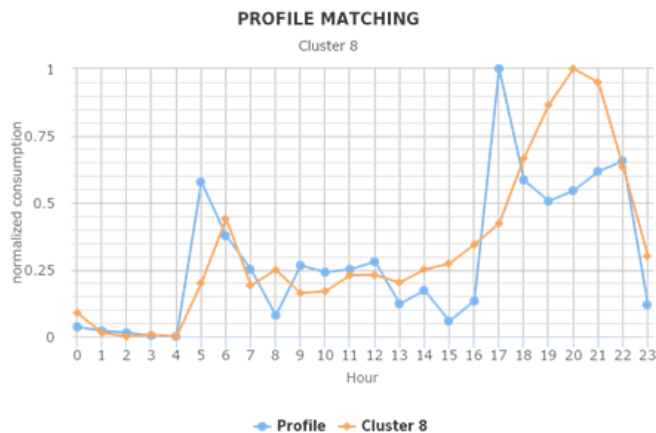


Fig. 4. Example of the profile matching

III. SUMMARY & CONCLUSION

The aim of the project was to build an application which draws the user's attention to his consumption behaviour and gives helpful advices to enhance his consumption profile together with orientation of their PV systems. In order to create consumption profiles a lot of consumption data, measured from the IZES, were evaluated and grouped into different clusters. After that it was possible to classify new consumption data and assign it to a specific cluster with the help of similarity analysis.

After all the application was able to match the users distinct profile to one existing cluster. In the search for a suitable algorithm for matching the consumption data was found out that a simple least square algorithm provides better results than all tested Neural Networks and Support Vector Machines. When refined and further developed, this kind of application can be a great help for the end consumers energy management and may facilitate the purchase of a PV system.

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Consequences of future data centre deployment on North American electricity generation and environmental impacts: a 2015–2030 prospective study

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Abstract—The environmental impacts of data centres that support information and communication technologies (ICT) are strongly related to electricity generation. Considering that electricity generation is a major source of green house gases (GHG) emissions, ICT and data centre usage are partially responsible for these emissions. With the increased use of ICT, more data centres are expected to be deployed in the future. Consequently contribution of data centre to global GHG emissions are expected to rise. However, electrical networks are very complex and dynamic systems. Therefore, an environmental evaluation of future data centres is uncertain. Indeed, the ecological footprint of the electricity consumed by the future data centres will directly depend on the technologies used to generate this electricity. In that context, this study proposes a new approach to investigate the consequences of future data centre deployment in Canada and optimize this deployment. This new methodology is based on the use of two combined tools. First, the Energy 2020 technico-economic model that is used to simulate the future evolution of the North American electric grid mix. Secondly, the life cycle assessment methodology (LCA) that evaluates the environmental impacts of electricity generation based on its entire life cycle and according to several environmental indicators (not only non-renewable energy consumed or GHG emissions): human health (6 indicators), ecosystems quality (6 indicators), climate change (1 indicator) and natural resources depletion (2 indicators). The main energy sources used in US and Canada are considered: biomass, coal, diesel, heavy fuel oil, hydro, natural gas, uranium and wind. Several prospective scenarios of data centre deployment in Canada are investigated: from adding 30 MW up to 750 MW by 2030 to the Canadian power demand of data centres. This method makes it possible to determine specific electricity

sources that will power the future Canadian data centres by comparing each scenario with a business as usual scenario. Therefore, the consequence on the Canadian electric mix can be modeled and the environmental impacts can be attributed specifically to the future data centres depending on the quantity of deployed data centres. Then the comparison of the environmental impacts per MW of deployed data centres makes it possible to optimize the global data centre deployment. Of the studied scenarios, the largest deployment of data centres (+750 MW) leads to the least impacts per MW of deployed data centres for most of the environmental indicators. Non-linear effects between power demand, electricity generation and environmental impacts are highlighted, disqualifying intermediate data centre deployment scenarios (+150 MW or + 300MW) due to their significant environmental impacts in comparison to other scenarios. It was also found that an increase in power demand by data centres would lead to a reduction in Canadian electricity exports to the US, driving the US to generate more domestic electricity to meet its energy demand. Since electricity generation in the US is globally more polluting than in Canada, the deployment of data centres in Canada is indirectly linked to an unwanted increase in environmental impacts due to the reduction in Canadian electricity exports. However, while an optimal solution should be found to mitigate world GHG emissions, it is not clear whether the environmental burden related to US electricity generation should be attributed to the Canadian data centres.

Keywords—*consequential life cycle assessment, electricity modeling, environmental impacts, greenhouse gas emissions, data centre deployment optimization.*

DC4Cities: Better Usage of the Renewable Energies in Data Centres

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Data centres are a key part of the ICT chain. The energy consumed by them in 2010 accounted for between 1.1% and 1.5% of the total electricity consumed worldwide [1], making of data centre energy management an important challenge for researchers. With the recent adoption of renewable energies to power data centres [2], the research community enlarges its vision to associate with purely *quantitative* energy consumption reduction, the notion of *quality* of the energy consumed, *i.e.* the capacity to rely as much as possible on sustainable power sources. Differently from non-renewable energy sources, the availability of renewable energies is very volatile and time dependent: *e.g.* solar power is obtainable only during the day, and is subject to variations due to the meteorological conditions. The goal in this case is to shift the workload of running applications, according to the forecasted availability.

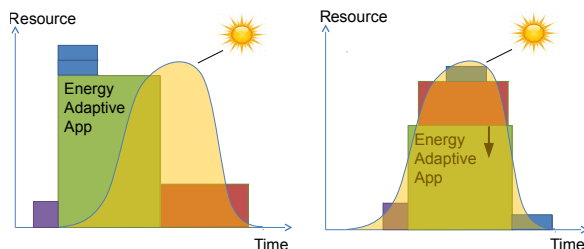


Figure 1. Adapting applications for a better usage of renewable energies

In our scenario, an entity external to the data centre called the Energy Management Authority is able to set high-level energy and power objectives for the data centre. For example, an objective can be: “at least 80% of the data centre energy consumption has to be generated from renewable energy sources”. To translate these high-level objectives into concrete actions performed in the data centre, our platform receives forecasts regarding the amount of available power and the energy source mix of its electricity inputs. These forecasts are either provided directly by the power suppliers or created by algorithms which use environmental and historical data to predict future renewable energy generation. Having both workload estimations for the different running applications [3] and the energy forecasts, our platform is able to assign specific power budgets to the different applications.

In order to run the applications in a data centre while respecting this power budget, we introduce the concept of Energy Aware Software Controller (EASC). The EASC is able to: (i) manage elasticity and scalability of multi-tier applications according to their energy footprint (*energy-awareness*); (ii) inject mechanisms in the single applications to negotiate energy

usage according to energy constraints (*energy-adaptiveness*).

The EASC implements workload scheduling techniques that can reconfigure the applications according to the power budgets (see Figure 1). An EASC is attached to each specific application running in the data centre and receives a different power budget, corresponding to the expected power consumed by the controlled application. The EASC is then proposing several plans to perform the application’s tasks, within the limits of its SLA. Those plans can be influenced using two weighted parameters: the aggressiveness and the eagerness. The aggressiveness controls the possibility for the application to consume more or less aggressively the renewable energies. For example, at a high aggressivity level the application will run at the highest performance level when renewable energies are available, and at the lowest performance when they are not. The eagerness controls the necessity for an application to complete its tasks more or less early. A low eagerness allow to be more flexible with regard to the scheduling of the applications tasks during the period of availability of the renewable energies. The EASCs are coordinated by the central component of our platform prototype. This central component coordinates the EASCs and selects the correct plan for each EASC, in order to optimize their combination.

A specific EASC has been designed to control the IaaS layer of modern data centres. It is used to consolidate the VMs that are running the applications, in order to free up some servers and switch them off when there is a low percentage of renewable energies. Similarly, an EASC for the PaaS layer is used to scale up and down PaaS applications with regard to their tasks, SLA and energetic situation.

Our solution has been trialled in the data centre of the health agency of the province of Trento, Italy. In this trial, the EASC was controlling a real application producing medical reports. We used an SLA stating that the application should be able to create 780 reports per day at minimum. Using our prototype, the percentage of renewable energy consumed by the data centre (called REN%) went from 43.1% up to 57.9%.

I. ACKNOWLEDGMENTS

The authors would like to thank the EU FP7 project DC4Cities (grant agreement number 609304), and the consortium members.

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Defining Green Profit in Distributed Datacenters

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Abstract—In this paper, a profit model is introduced for distributed datacenters which work in a job-scheduling business model, in order to maximize their profit. A “virtual carbon tax” is also introduced to artificially add a virtual cost to the profit model, resulting in a virtual profit (green profit). Simulation results show that job scheduling based on green profit balances the tradeoff between real profit and environmental footprints of the datacenter (a small loss in profit results in a large environmental impact reduction).

Keywords—virtual carbon tax; green profit; profit maximization; sustainability; environmental footprint

I. INTRODUCTION

By nature, datacenters (excluding their emergency power system) are carbon neutral, but the electricity consumed in them is not. The electricity mix of the power grid is determined by distribution of its power plants with diverse technologies ranging from coal to hydro. Knowing the exact mixture of electricity mix, one can calculate its environmental footprint. It is worth noting that electricity mix has a dynamic but semi-periodic nature relative to time zone, time of day, and season, among other parameters.

In reality, the electricity price only includes electricity generation cost and does not represent its real cost which includes the cost of offsetting its environmental footprint. Not many jurisdictions are imposing strict policies towards real electricity cost, and therefore for-profit organizations may not care about the greenness of the electricity mix. Having said that, some corporations such as Google, Apple, and Facebook are taking voluntary actions towards this direction [5].

This paper provides geographically-distributed datacenters (which are connected to different electricity mixes) with a model to maximize their non-green profit even with a simple job scheduler [2]. Then, it imposes a voluntary *virtual carbon tax* to the profit model to balance the tradeoff between maximizing profit and minimizing environmental impacts. When *virtual carbon tax* is added to the model, it is more profitable (green profit) for the datacenter to schedule new jobs in locations with lower environmental footprint.

II. PROFIT MODEL

Equation (1) calculates the profit generated by a single CPU core (working at frequency f) during an hour, namely ‘Profit per Core Hour GHz’ (PpCHG). To calculate the total profit, one must sum up all the applicable PpCHGs over all the cores and operating hours.

$$\begin{cases} PpCHG(f) = revenue_{core,hour,f} - cost_{core,hour,f} \\ cost_{core,hour,f} = OPEX_{core,hour,f} + \\ electricity_{core,hour,f} * electricityRate + \\ coolingElec_{core,hour,f} * electricityRate \end{cases} \quad (1)$$

Having $PpCHG(f)$, it is possible to calculate the optimum frequency which maximizes the PpCHG ($PpCHG(f_{opt})$). Figure 1 illustrates $PpCHG(f_{opt})$ where DVFS model is valid: $electricity_{core,hour,f} = \beta + \alpha f^3$ [1].

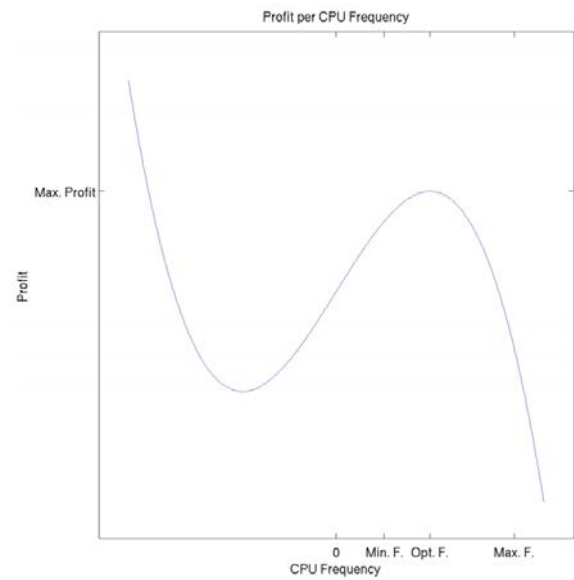


Figure 1 - $PpCHG(f_{opt})$

III. SCHEDULING BASED ON PpCHG

Figure 2 shows $PpCHG(f_{opt})$ for several location during a week (Each 160 cores are located in a different time zone). Darker areas are associated with lower profit. A scheduler can use this map to avoid low profit areas to maximize the total profit.

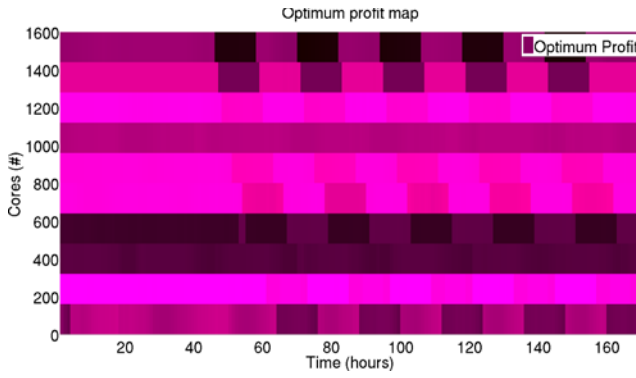


Figure 2 – Distributed datacenter maximum-profit map

IV. IMPOSING VIRTUAL CARBON TAX

Equation (2) adds an imaginary carbon tax¹ to Equation (1):

$$\begin{cases} PpCHG(f) = revenue_{core,hour,f} - cost_{core,hour,f} \\ cost_{core,hour,f} = OPEX_{core,hour,f} + \\ electricity_{core,hour,f} * electricityRate + \\ coolingElec_{core,hour,f} * electricityRate + \\ carbon_{core,hour,f} * virtualCarbonTaxRate + \\ coolingCarb_{core,hour,f} * virtualCarbonTaxRate \end{cases} \quad (2)$$

V. SIMULATION RESULTS

A distributed datacenter located in ten time zones is tested under three schedulers: a profit-aware [3,4], a carbon-aware [2], and a green PpCHG-aware. Figure 3, Figure 4, and Figure 5 illustrate the actual schedule of HPC jobs by these schedulers. Each job is colored with an RGB color (red: frequency, green: greenness, and blue: electricity price).

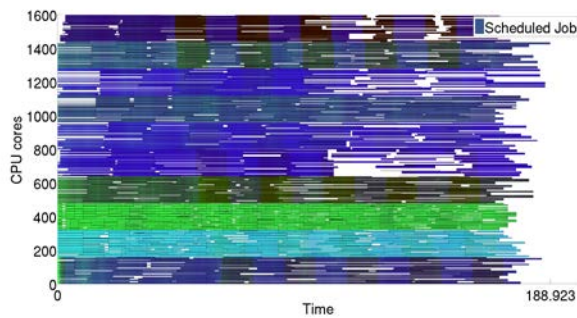


Figure 3 – Carbon-aware job scheduler

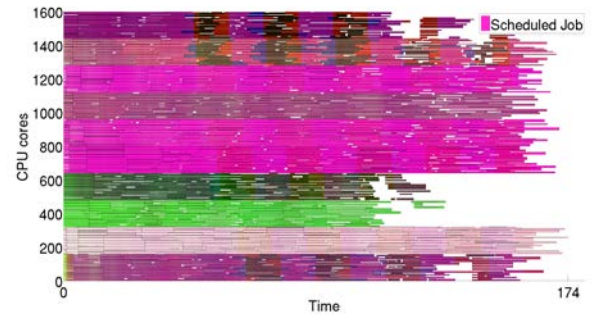


Figure 4 – PpCHG-aware job scheduler

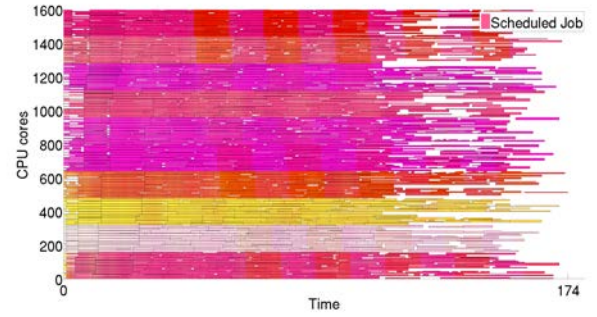


Figure 5 – Profit-aware job scheduler

Carbon-aware scheduler tries to avoid non-green areas and reduce the frequency of CPUs. Profit-aware scheduler increases the frequency of CPUs, and PpCHG-aware scheduler avoids non-profitable areas (for example, by avoiding electricity peak hours or reducing the frequency during the peak hours).

Figure 6 shows the tradeoff between profit (\$) and carbon (Kg) for all three scheduler. PpCHG results are shown with triangles for a range of virtual carbon tax rate from 0 to \$0.60/kgCO₂-eq.

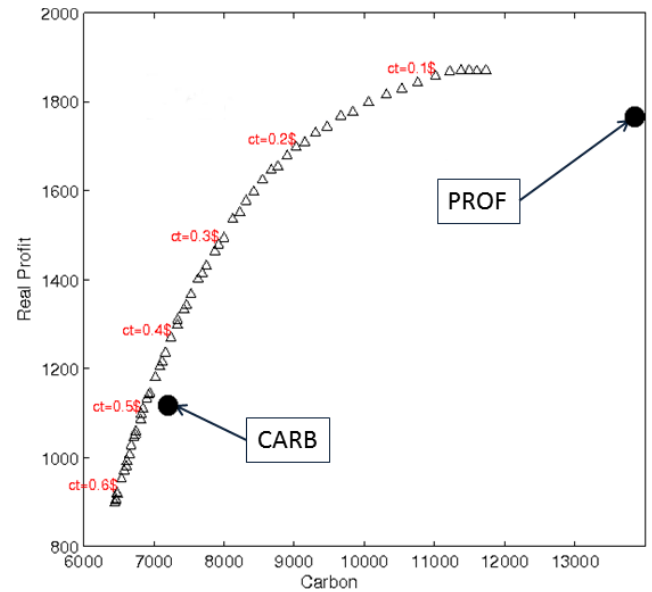


Figure 6 – Carbon-profit tradeoff

¹ Virtual Carbon Tax (\$) = Carbon Footprint (kgCO₂-eq) * Virtual Carbon Tax Rate (\$/kgCO₂-eq)

VI. CONCLUSION

This paper uses a profit model for a core-hour unit to calculate and maximize the total profit of a distributed datacenter. A *virtual carbon tax* was also added to the profit model in order to enable voluntary minimization of the carbon footprint of the datacenter.

A typical profit-aware scheduler will maximize the profit, but it also maximizes the carbon footprint. A typical carbon-aware scheduler will minimize the carbon footprint, but it also minimizes the profit. In a PpCHG-aware scheduler, a balanced solution can be achieved by choosing the right amount of *virtual carbon tax rate*.

Other Virtual Sustainability Taxes will be addressed in our future works such as Virtual Manufacturing Tax, Virtual Toxic-Wastes Tax, and Virtual End-of-Life Tax, among other parameters in Life Cycle Assessment of datacenters. We also plan to apply Virtual Carbon Tax to larger use cases using real-world datacenter traces.

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Does having a green conscience necessarily lead to green outcomes? Results from an Agent Based Model for agriculture in Luxembourg

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Life cycle assessment (LCA) is a standardized methodology used to quantify the environmental impacts of products across their whole life cycle [1]. LCA is an assessment methodology recognized worldwide, although with some limitations and barriers, as witnessed by [2].

In the MUSA (MULTi agent Simulation for consequential LCA of Agro-systems) project ¹ we wish to simulate the future possible evolution of a farming system, accounting for social and behavioral aspects of the agricultural systems, including the effects of introducing a 'green conscience'.

Here we investigate the influence on the overall environmental impact of a system of introducing LCA results into ABMs. The main question remains how to use the specific results of an initial LCA within the decision process of farmers. In the results we present here, we focus on the question of which environmental impact indicators to use. We use an agent-based model where agents perceive the results of an LCA for the full agricultural system and use them in the farm planning.

Our ABM is built as follows: the farmers are represented via entities called "agents" who take decisions based on their individual profiles and on behavioral rules defined by the researchers on the basis of the observation of real world (e.g. the results of a survey). ² The simulation workflow is as follows: 1) Initialize the farm sizes, 2) Assign to each farm a random rotation scheme and a set of crops being planted (depending on the rotation scheme), 3) Scale the sizes of the farms and the fields to match the statistics of 2009 and 4) apply the behaviours associated to each agent.

We used the ReCiPe impact assessment method [8] to obtain the potential life cycle impacts based on the following indicators: *climate change, ozone depletion, terrestrial acidification, freshwater eutrophication, marine eutrophication, human toxicity, petrochemical oxidant formation, particulate matter formation, terrestrial eco-toxicity, freshwater eco-toxicity, marine ecotoxicity, ionising radiation, agricultural land occupation, urban land occupation, natural land transformation, water depletion, metal depletion and fossil depletion*.

We propose three behaviors for the farmers:

- 1) **Pure profit maximization.** the farmers rank crops according to their profit potential given the past prices, forecasted price and the crop rotation constraints on substitution of existing crops.
- 2) **Pure environmental concern ("green conscience").** To incorporate the "green conscience", we have a matrix of life cycle impact assessment (LCIA) indicators (the 18 mentioned previously) for 1 ha of each available crop. Each farmer would then choose a set of crops that are likely to have the least adverse environmental impact and the aggregate of all farmers' choices will determine the global environmental impact.
- 3) **Mixture of the previous two.** These three would be to assign a weight between 0 and 1 for the "green conscience" and pure profit behaviors and obtain the life cycle impacts.

For exemplification purposes, we ran 5 simulations with the ABM model and we computed the corresponding variations in the cultivated area of each crop. These variations were fed to a LCA software, which calculated the corresponding midpoint LCIA results.

Simulations were run with the following parameters:

- Each farmer has a random green conscience, taken from a uniform distribution between 0 and 1
- Each simulation is executed only over one year
- All agents perceive in perfect conditions the available crops in the environment as well as the LCA results.
- Each agent has only one post-market behavior: green conscience.

Initial results concerning LCA suggest that if a farmer solely focuses on CO_2 as criterion for his decisions, and has a "green consciousness" that compels him to make changes in his rotation scheme, he may end up improving the carbon footprint of his produce, but may worsen other environmental impacts that could be of higher importance for his specific activities, for example those related to soil and water. This is an initial solution to the question of how to include the LCA results in an ABM model that is not free of collateral effects: while optimizing for one criterion, we end up with other criteria (like eutrophication) being worsened.

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²The interested reader may look at [7] for the details of the LCA model created for the environmental assessment of the Luxembourgish agricultural system.

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eReuse.org: an ecosystem for traceable reuse of digital devices in a circular economy

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Many digital devices —such as desktop, laptop, tablet or mobile computers— from businesses and public organizations are dismantled and recycled when amortized or out of guarantee despite being nearly up-to-date and in perfect condition to use. Reuse of digital devices ensures recycling and effectively contributes in generating circular economy, preventing waste generation, reducing the risk of WEEE (Waste Electric Electronic Equipment) such as leakage to landfills or illegal exports, creating jobs, and strengthening digital skills [1]. Reuse can also contribute in reducing the digital divide, and strengthening institutions and projects for social change. However, why is it a minority practice? When companies, governments, or individuals need to get rid of their digital devices through reuse, they don't know where to turn. This scenario results in most EEE being recycled (dismantled) too early despite of the explicit demand for reuse coming from social and charity organizations.

Although the volume of e-waste is growing three times faster than other types, recycling plants collect less e-waste. This paradox is mainly attributed to pillaging in collection points or by home collection done by unauthorized operators [2]. Our pilots show that in public institutions more than 80% of the devices to be recycled can be operational. There is a demand for these devices even without any upgrade or repair. Recycling of digital devices with reuse potential is ineffective, and more serious in countries under economic crisis given the lower social value and higher environmental cost of recycling a device that could be reused. In Europe only 33% of EEE Waste is reported as collected and treated. The remaining is a leakage: 13% goes to EU landfill and 54% to substandard treatment inside and outside the EU (illegal trade to 3rd countries) [3]. According to the International Environmental Technology Center of the United Nations Environment Program (UNEP) [4], e-waste is the fastest-growing type of waste, particularly in some developing countries, where the volume is expected to grow by up to 500 times over the next decade. Out of which, 80% is estimated to go into landfills and incinerators.

For the reuse sector to flourish, donors, receivers, and reuse centers need support services and technologies to gain effectiveness, efficiency, and traceability to reach the goal of extending the life of such devices, and to ensure their final recycling. Our proposal is to enable direct donations of reusable or repairable devices, and to guarantee that any reused device is eventually recycled properly. Devices are prepared for reuse with traceability in donors' locations, as depicted in the poster at the end. This system minimizes losses because there is no need to transport or centralize the EEE. Social enterprises (preparators) active in reuse and repair are also included in this

ecosystem. In our pilots, donors mostly delegate preparation for reuse tasks (hardware rating and testing, deletion of data, inventory, labeling and packaging) to reuse centers. Preparators take only products that need to be repaired or refurbished and recycled if they are authorized collectors.

The main challenges to overcome are: access to enough volume of good quality used devices, quick preparation of those with more potential for reuse, enablement of direct donations, guarantee for reused devices are finally recycled, communication of reuse's social and environmental value, reward for donors, and commitment to receivers of reused devices with recycling.

This poster presents eReuse.org: a set of open source tools based on a distributed platform ecosystem that support direct donation of devices and its traceability. Devices are prepared for reuse in the donors' location, and receivers collect them. Malicious users are discouraged by a reputation scheme to reward cooperative receivers that reuse devices and track them until disposed to recycling agents. This system reduces costs, and minimizes EEE losses as there is no need for central logistics or centralizing the engagement of donors on charity projects. The initiative follows an open model (unrestricted), as the goal is to bootstrap the reuse process, to generate local efficiencies, to guarantee final recycling, and to ensure traceability. Pilots already performed for more than four years on two thousand devices validate the model with 80% traceability of device components. The result is a global ecosystem for effective, efficient and traceable reuse of digital devices with final recycling.

ACKNOWLEDGMENT

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Estimating the carbon footprint of watching video from the BBC

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Keywords—Carbon footprinting; digital media; sustainability;

I. CONTEXT AND MOTIVATION

Video consumption has been identified as an important driver for energy consumption of the internet [1]. At the same time, the energy consumption of other distribution channels such as terrestrial broadcast or satellite television (TV) was found to be less energy efficient than digitally distributed video-on-demand content (VOD) under some circumstances, specifically for less popular content [2]. The growth of energy consumption by ICT systems and the network in particular could become unsustainable [3] and is potentially facing a crisis [4]. In order to take stock of the present energy consumption and carbon footprint with a view to assess the current and future sustainability of video consumption, we are performing a comprehensive assessment of the carbon footprint of the delivery and consumption of video from the BBC, the largest broadcaster in the world.

II. METHOD

For this assessment we perform a life cycle assessment of the use phase energy consumption. The scope of the assessment includes the following devices:

- user devices such as desktop and screens, laptop, smartphones, tablets, televisions, gaming consoles, projectors
- home networking equipment, such as modems and WiFi routers, set-top boxes and media players
- access and core networks
- data centre energy consumption (mainly servers but also storage and ancillary equipment)

Among the environmentally relevant impacts, we are including carbon footprints from the consumption of electricity during the use phase. From the operational activities of these devices we include energy consumption during delivery, storage and consumption of the content.

A. Models

Carbon emissions are estimated from the energy consumption of devices and the carbon emission intensity of

the electricity at the location of the devices. For devices with low energy elasticity during providing the functions relevant to the assessment (delivery and consumption) energy consumption is estimated as the product of duration of use and the average power consumption per device class. In particular this is case for: user devices, satellite antennas and terrestrial antennas. For equipment directly operated by the BBC, some primary measured data of energy consumption is applied. For the remaining device types used for digital delivery over the internet energy consumption is estimated relative to the data volume of the video services. The energy and carbon footprints will be estimated in a bottom-up fashion around the functional unit of a single video in order to enable scenario analysis from the perspective of the consumer as well as the BBC.

III. RESULTS

The main results will include an assessment of the absolute energy consumption and carbon footprint. Part of the results will be an interpretation of these results in the light of the problem situation of potentially unsustainable media which might include comparison to other areas of household energy consumption or infrastructure. Given that video is the main driver of capacity expansion of the internet, is likely that the resulting estimated footprint is substantial relative to other factors in UKs national energy consumption budget. A comparison of all the various delivery types on the unit of an individual video will also allow to identify the most energy/carbon efficient mode.

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Feature extraction to characterise and cluster the energy demand of UK retail premises

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Introduction

Non-domestic buildings account for approximately 10% of UK greenhouse gas emissions [1] of which retail has the largest portfolio. The use of automated meter reading and building energy management systems is prevalent to monitor and evaluate energy use. However, the deployment of sub-metering within the building is less common. For facilities managers of companies with multiple stores, the detailed evaluation and comparison of different sites is becoming increasingly important requiring new and advanced analytical techniques not currently in common use. One such technique is automated clustering [2] to create groups that show similar behaviours, with the aim of understanding and finding unusual events. However, before applying these techniques, the general behaviour to be clustered should be represented in a meaningful and concise way. The temporal resolution of the profiles (from seconds to hours) has an impact on the clustering results [3].

Methodology

In an automated fashion, we obtain and exploit features from the daily electricity load profiles provided by a UK retail company. We demonstrate that a generalised set of features can represent the essential information of the consumption of UK retail establishments. The daily energy profile (the continuous line) in Fig. 1 is typical for a UK store. It presents a value for each one of the time intervals independent of there being a significant event *e.g.* night-time values can be considered constant. The single broad peak shown is directly related with their opening and working times.

Considering these characteristics, we propose to summarise the establishment's behaviour with eight features extracted from the profile: the start and end times of the peak, the start and end times of the stabilisation of the peak/off-peak periods *i.e.* t_0, t_1, t_2 and t_3 , the average during the peak/off-peak phases *i.e.* $\mu(s_0)$ and $\mu(s_2)$, and the slope of the transition between the peak and off-peak periods *i.e.* $m(s_1)$ and $m(s_3)$. We can then compute an approximation to the real profile — the dashed line — and select the set of features with the smallest Euclidean distance between the approximated profile and the real profile.

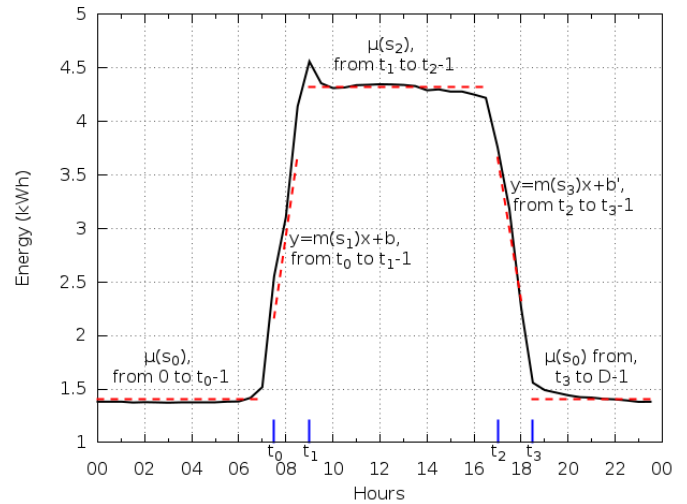


Fig. 1. Approximation to the real profile (continuous line) of a store based on the proposed features.

Results

We performed experiments on a dataset of more than 600 stores (from a single company) with electricity meter readings at thirty minute intervals acquired between April 2013 and October 2014. The eight proposed features were extracted from each store's Monday-to-Saturday profile. Then we applied a clustering algorithm based on the Gaussian Mixture Model [4] to group stores with similar behaviour. The resulting four clusters (using the slope values) are shown in Fig. 2. In this example, the number of stores in each one of the clusters is 84, 376, 64 and 118 for clusters 1, 2, 3 and 4 respectively.

Figure 3 shows the energy profiles representing the cluster centroids. There are clear differences in the magnitudes of the peaks for three of the four cluster centroids. Clusters 1 and 2 show similar consumption during the peak. However, the off-peak values of cluster 1 are significantly higher than in cluster 2. For these two clusters, there are also clear differences in the slopes.

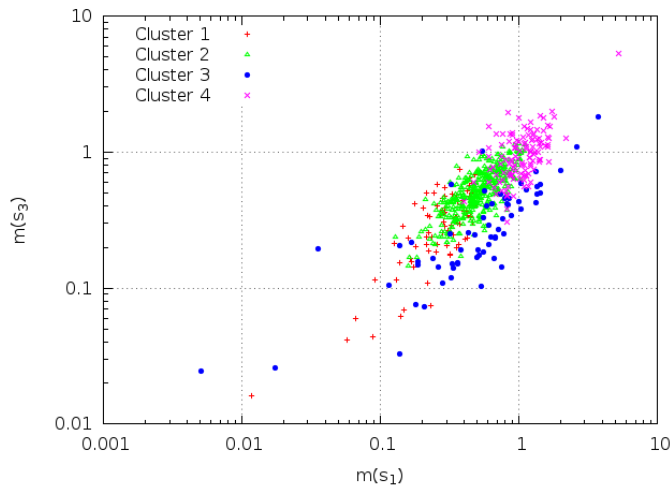


Fig. 2. Values of $m(s_1)$ against $m(s_3)$ depending on the store cluster.

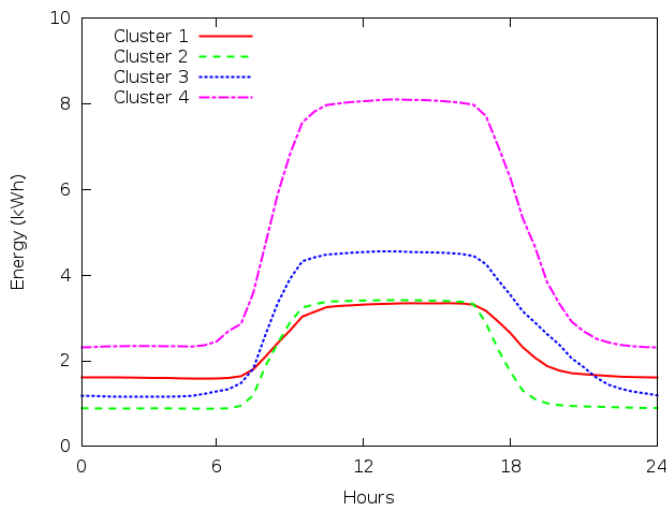


Fig. 3. The centroids of the obtained clusters.

Conclusions

We have presented a concise method to extract a set of features to represent the energy profiles of UK retail premises. Using these features we have clustered the stores and obtained distinct behavioural groups. As we represent each customer with a small number of features, combining features obtained from different profiles of the same customer *e.g.* gas/electricity, weekend/weekday, Summer/Winter, is relatively easy. Furthermore, the proposed features are independent of the temporal resolution of the profiles, allowing us to compare customers with different resolution profiles.

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Guidance on applying Green ICT in Higher Education and Research

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The field of Green ICT is associated with minimizing the negative environmental impacts of ICT and optimizing the positive impacts of ICT. Even though the global environmental impact of ICT itself is significant (roughly 2%), making something else more efficient has a much larger effect (potential reduction of 16% of the global footprint) [1]. While both aspects are widely recognized and can be understood on an abstract or global level, it is often difficult for individuals or organizations to apply them.

The SURF Green ICT Maturity Model (SGIMM) was created to address this issue. The SGIMM is designed to give organizations insights into the maturity of Green ICT of the organization. It is set-up as a self-assessment and enables organizations to have an internal dialogue, to gain agreement on the status quo and to define actions for improvement. By letting several individuals within an organization score the attributes and discussing these scores with the participants an organization can identify weak and strong Green ICT aspects.

The concept of the maturity model is based on the Capability Maturity Model, representing a framework with five maturity levels for quality and process improvements. The five levels are (1) initial, (2) repeatable, (3) defined, (4) managed and (5) optimizing. At the lowest level, the initial level, the organization does not provide a stable environment for the activity. At this level the process is ad hoc. However, at the highest level, which is the optimizing level, the entire organization is focused on continuous process improvement [2]. Further inspiration was drawn from the work done by Curry and Donnellan [3].

The SGIMM conceptually consists of four domains covering negative and positive impacts and aspects of ICT. Each domain consists of attributes that have a definition, factors involved and descriptions of each of the five maturity levels. Three domains and attributes are generally applicable to any organization, being: "Green ICT in the Organization", "Greening of ICT" and "Greening of Operations with ICT". The fourth domain is sector-specific and covers 'Greening of primary processes with ICT'. For instance, for the higher education sector (main focus of our research), the primary processes would relate to education and research. More information on the SGIMM can be found in [4, 5].

A few models and frameworks exist that help apply Green ICT principles to primary processes in an organization. For example, the framework in [6] contains the capability building block "ICT-enabled business processes". They found that involving the ICT department as well as 'business' raises awareness on both sides of the potential of

Green ICT. However, the framework seems to remain high-level and offers little practical guidelines to apply Green ICT to business processes. In general the impression we gather from other work, and this is also what we experience, that it is difficult to apply Green ICT outside the datacenter.

With the poster we want to demonstrate how the SGIMM could offer practical guidance for Green ICT in primary processes. We have developed a sector-specific domain in SGIMM for the higher education sector using the principles of the maturity model described above in combination with a reference architecture that was developed for the Dutch Higher Education [7]. This reference architecture contains detailed material on processes in Higher Education that we could reuse for the maturity model.

Using the Higher Education sector-specific domain as an example, we can now define the general steps to develop such a domain. These steps can be used as guidance for other sectors, too. They are:

1. Find a well-grounded description of the sector activities and processes, for example a reference architecture. If such a description is absent, one could proceed with a description of the enterprise architecture of a single (typical) organization.
2. Identify the main primary processes or functions. For example: education. These are the attributes in the sector-specific domain.
3. Find detailed descriptions of the previously identified attributes to deduce building blocks or process categories. For the attribute 'education' these categories are (amongst others): teaching, examination.
4. Describe the maturity levels for each attribute. This can be done in two ways:
 - a. Use general descriptions of maturity levels [2, 3] and make these more specific based on the architecture (this is what we have done).
 - b. Use the identified process categories, give them individual scales of improvement and use a combination of the scales to describe each level.

We are currently testing the use of such a domain focusing on the primary processes in combination with the use of the rest of the maturity model by observing a number of Higher Education institutions that are applying the model in practice. One of the positive benefits already identified is that it raises awareness of the possibilities of green ICT as an enabling force, also outside of the ICT department or specialists in an organization.

Keywords—*Green ICT; Maturity Model; ICT for Sustainability*

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The Role of Practices in the ICT Revolution

Crucial Social Processes from a Sustainability Point of View

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Keywords—*social practice theory; sustainability; ICT revolution;*

I. POSTER ABSTRACT

The poster presents the conceptualization of two processes regarding how an *ICT-practices-revolution* relates to environmentally sustainable development. It is also based on the argument that there is an ongoing (and by now well-established and taken-for-granted) ICT revolution, which mainly consists of a social practices-revolution in co-development with an equally significant industrial revolution. In this change environmental consequences of human patterns of activity are also significantly changing. We argue that any actor or individual who aims at contributing to sustainable development would benefit from being aware, and when possible take advantage, of the practices aspect of the ICT revolution. Therefore our poster addresses the practices aspect from an empirical and interpretative perspective. In relation to this we argue that *how much* and *at what* (quantitatively assessable) *rate* patterns of action change is equally significant to investigate as *how* they change. Having stated this we focus on the *how* side, or rather on what we call the sociological interpretation of (main) processes of change.

Based on an interview and diary study in Stockholm 2015 we postulate the following processes of changing practice:

1) The process in which an alternative of specific practice is unfolded, so that ICT-use becomes crucial for performing it, in contrast to another (older) way of performing, e.g. when to purchase online becomes an alternative to doing it in a conventional store.

2) The process in which ICT (use) on the overall level contributes to shaping a different (and environmentally significant) mix of social practices in society.

As an example of the above processes we here use the specific media practice of 'taking part in public discussions and debates' carried out through using internet (-connected devices) and social media. This practice is still performed also by using older ways of communicating and by using older devices, media platforms etc. As a part of the ICT revolution alternative means are clearly unfolding for performing the practice of debating and discussing, and the balance is changing between newer and older ways of practicing it. We found that this change came about through people becoming (more active) participants in them, and in parallel, step by step abandoning

the alternative media practice where ICT-use isn't crucial. (We welcome a discussion regarding the specifics of such a process in the poster session). A special and interesting case of the 'taking part in public discussions and debates' media practice was environmental activism (for which use of social media was essential). In line with the above our poster emphasizes *how* practices change, when ICT:s are being put to new uses. They change through the social process where

a) learning, imitating and sharing is taking place within – and at the borders of – a community of practice (i.e. a group of interacting people), and

b) new practitioners are being *recruited* [1, 2].

Finally, the poster indicates how knowledge of these social processes could throw light on shady spots in well-cited studies, regarding the development of ICT in relation to the development of more or less sustainable patterns of action and consumption. Within this area of research it is put forward that ICT:s could be 'put to use for', or 'lead to effects of', optimizing, substituting, dematerializing or inducing production and consumption [3, 4]. When framing processes in such a way there is a lot of attention paid to *how* practices evolve, which we argue is a fundamental in the ICT revolution. We found in our study, much in line with [5], that practitioners carry out action which is meaningful and important to them in a multitude of ways, other than in terms of optimizing, substituting etc. On the micro-level of ICT-related practices 'practical know-how, bodily activities, ideas and understandings' [5] etc. are employed in trial-and-error like, socially negotiated feedback processes where alternative and new mixes of practices ensue in ways that could be understood in more detail to provide actors with opportunities for affecting practices in transition.

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Information bottlenecks for local strategies to reduce greenhouse gas emissions

An explorative study of municipalities in Uppsala County

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Abstract—Many decisions and activities to decrease greenhouse gas (GHG) emissions in Sweden have to be performed at local and regional levels. The main purpose of this explorative study is to gain knowledge of how information related to GHG emissions is used by community planners and decision makers. Preliminary results from interviews with community planners and regional planners in Uppsala County show that high quality emission data and standardized data management methods are lacking. There also seems to be lack of awareness and understanding of the importance of the climate issue within the local authorities.

Keywords—Greenhouse gases; information strategies; Uppsala; emissions

I. INTRODUCTION

Despite all ongoing research regarding climate change and mitigation, greenhouse gas (GHG) emissions for Sweden are not decreasing nearly as much as they need to, in order to meet the national goals set for 2050 [1]. Even though goals are set at national and EU levels, many decisions and activities to reduce GHG emissions have to be performed at local or regional levels.

To find out what kind of information related problems and bottlenecks exist at local and regional government levels regarding GHG emissions, an explorative study has been made, investigating municipalities in Uppsala County from an informational perspective. The main purpose of this study is to gain knowledge of how information regarding climate change and emissions is used by community planners and decision makers. It is intended that results from this study can be used to improve local and regional information strategies, ideally having a decreasing effect on local GHG emissions in a near future.

We formulated three preliminary research questions to explore this issue:

- What are the largest problems/bottlenecks regarding climate related decisions, perceived by community planners and regional planners?

- What information basis do decision makers need to be able to make decisions involving GHG emissions?
- What kind of information regarding emissions/climate do community planners need and in what form?

II. METHOD

Exploratory, semi-structured interviews were held with community planners at municipalities in Uppsala County and regional planners from the County Administrative Board for Uppsala County and Uppsala Regional Council. A preliminary analysis was made on interview notes and the interviews that have been transcribed so far. The interview transcripts have been inductively coded and categorized, using conventional content analysis, to shed light on information related problems and other relevant existing bottlenecks [2].

III. PRELIMINARY RESULTS

Based on the preliminary analysis, the most widespread problem for the community planners seems to be lack of awareness, knowledge and understanding of the importance of the climate change issue in collaborators such as decisionmakers, politicians and fellow officers.

The eight municipalities in the region have quite different preconditions, where larger municipalities tend to have more resources for climate-mitigation activities, compared to smaller municipalities. Some municipalities want more recent, high quality statistics of local CO₂ emissions. For example, in some cases emission data are delayed 20 months or more before reaching municipalities. Standardized methods on how to obtain, manage, aggregate and present the data are also lacking. Other municipalities do not have enough resources to tackle statistics, but instead want to focus their efforts on climate mitigating actions. Knowing which actions that would have the largest effect on reducing GHG emissions and how to communicate emission consequences of actions to decision makers, is also a problem.

Moreover, there is a lack of clear, useful, local and regional climate goals, better connected to the national climate goals for Sweden.

IV. DISCUSSION AND PRELIMINARY CONCLUSIONS

More interviews can be held for further clarifications of the current preliminary results. There are also plans for interviewing some municipalities outside Uppsala County. The final results will later be compared with existing frameworks for information quality and other relevant aspects [3].

The lack of high quality emission data as well as standardized methods puts a heavy burden and responsibility on the shoulders of individual community planners. It is our vision that a user-centered, pedagogical information system for handling local GHG emissions, including different scenarios

for the future, could facilitate such efforts, supporting development of better climate related decisions at local and regional levels.

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Monitor and protect future potential Giant Panda habitats and staple bamboo resources by applying Geographic Information System (GIS) application combined with Cellular Automata (CA) modeling

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Abstract—Bamboos are the most important diet choice for the wild giant pandas.

In 1975 and 1983, more than 200 wild giant pandas died due to the flowing of *Fargesia* in their habitat [1]. Pandas' existence depends on the amount and quality of their staple bamboo species. To monitor and predict the distribution and the amount of these bamboos in the pandas diet, will deepen our knowledge of their habitat and future survival. Also it will give scientific support on the panda's habitat quality, patch/island effect and ecological capacity.

For a long period of time, typical research methods for these bamboos were focused on microbiology and national reserve observation and sampling. Key research focuses are mainly about bamboos' species and distribution; ecological, biological, physiological and biochemical characteristics [1-5]. As scientific research evolves, the methods of analyzing bamboos has be brought to another level, many researchers apply GIS technology for monitoring and calculating their distributions [5,6], combined with neural-network methods to improve predictions for ensuring accuracy [7].

These researches have been proven well for statistically analyzing bamboo distribution and quantity, but none can predict how its future statues will be. Although evaluation research on pandas' habitat [8-10] has been using the amount of bamboos as an element of statistical factor, nothing has been conducted on the prediction of the pandas' staple bamboo species distribution shifts.

The location of research is Dafengding- Mabian National Nature Reserve in Mabian Yi, Leshan City, Sichuan Provience. Little research has been conducted there compare to the popular reserves such as Wolong National Nature Reserve in Sichuan Provience. It's unique location holds about 30 wild giant pandas along with living fossil vegetation and staple bamboo species of the giant panda, it's one of the key nature reserves in China with a high conservation value [11].

The research method will be focusing on the habitat evaluation system and GIS, combine with CA model, to build a dynamic simulation model of Da FengDing area, specially focusing on the environment of the staple bamboo species in the

pandas' diet. The simulation will predict the future quantity and distribution of those bamboos, and will be providing a visual analysis to assist future conservation.

It will start by applying Pressure State Response (PSR) model to create a habitat evaluation index system for the pandas' staple bamboo species in Da FengDing nature reserve. The focus will be on the aspects of environmental pressure, survival status and protection response. Environmental pressure includes urban sprawl, deforestation and other human activities and natural disasters that bring pressure for survival; survival status includes the quantity, quality and growth rate of the staple bamboos in the area; protection response includes management measures taken by the national and international community and environmental protection and possible countermeasures.

It will continue to the use of Analytic Hierarchy Process analysis for the weight of Dafengding Nature Reserve evaluation index. In accordance with the target layer, criterion layer, feature layer and index layer, the establishment of a hierarchical model will standardized the method to obtain the results of the final weight of the variance index.

Finally, the evaluation index system and index weights of the bamboos distribution data of Dafengding nature reserve will be embed to the GIS data platform of Dafengding reserve, with the combination of CA model, we will build a CA Model of bamboos' habitat assessment simulation. Using historical data (1995, 2000, 2005 and 2010), to gain the validation and correction of the model, the simulation will be applied after the 2014 model is complete. The model will be the basic guideline for the conservation of habitat quality in Dafengding nature reserve, and to predict and protect future stock and environment quality of staple bamboo species in the giant pandas diet.

Keywords—*Giant Pandas; bamboos; habitat quality; GIS; Cellular Automata modeling*

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Phone-based presentation of other commuters' subjective experiences: impact on car-driver intentions

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Abstract — Previous research demonstrates that people using active modes of transport (e.g. walking or cycling) generally report more positive subjective wellbeing than car drivers. This study demonstrates an experiment investigating the impact of this information on car drivers. We designed a smartphone application (CommuterExperience), which captures drivers' subjective experiences (via comments and ratings) after the commute and displays similar data from other people using different modes of transport. After a two week trial, participants (n=18) were interviewed and qualitative data were analysed. We evaluate how the application managed to encourage comparison, foster reflection and ultimately influence opinions, intentions to change and, potentially, behaviour.

Keywords — *behaviour change; sustainable transport; smartphone application; travel behaviours; social comparison; reflection; persuasive technology;*

I. INTRODUCTION

Information and communication technologies (ICT) have the potential to influence people's behaviours towards active modes of transport such as walking and cycling. A number of studies can be found in the literature using ICTs, both to reduce CO₂ emissions [4, 5] and also to promote health physical activities [6].

There is evidence that the modes of transport people use and their individual travel behaviours influence the way they feel. Those who walk and cycle frequently present higher life satisfaction than car drivers and users of public transport [7, 9,

10]. The active commute provides a number of benefits such as a healthily physical exercise, harmony with environmental values, feelings of autonomy, lower costs and less stress [1].

This research tries to influence travel behaviours leveraging on people's wish to improve their own levels of happiness. Instead of nudging travellers using environmental concerns, financial costs or health benefits, this study attempted to show participants the possibility of improving their subjective wellbeing if they opt for active modes of transport.

Social comparison has been shown to motivate behavioural intention to engage in a given behaviour [11]. It is expected that, when car drivers see other people's subjective experiences (SEs), it will foster reflection and make them reconsider the way they travel. Persuasive technology [3] and behaviour change support systems [8] are used as the methods to promote social comparison and stimulate reflection [12].

II. STUDY DESIGN

This was a feasibility study of an intervention delivered via a smartphone application. Car drivers (n=18) were randomly split in two groups of 9 (control/experimental condition). The intervention was deployed for 2 weeks and all participants input comments and ratings about their commutes to and from work. At the end of the trial we conducted semi-structured interviews where participants were asked to comment on other people's SEs and how they would feel if they were to cycle or walk to work. A thematic analysis of interview transcripts was performed using QSR International's NVivo 10 software.

A. Intervention description

1) Self-monitoring of travel behaviour (automatic detection of mode of transport);

The app used combined geolocation data to identify routes, modes of transport and distances travelled.

2) Feedback on past transport behaviour (visualisation of personal behaviours);

The app presented a list of journeys by mode of transport, time and distances.

3) Self-monitoring of outcomes of behaviour (sampling of subjective experience);

The app displayed on the initial screen two elements to capture participant's SE: a 5-point 'smiley face' rating and a text field for comments about their most recent commute.

4) Social comparison, feedback on others subjective experience (visualization of others' subjective experience).

After rating a journey and submitting a comment, the user was redirected to either a thank you page (control condition) or a list of other people's ratings and comments (experimental condition). These ratings and comments were created by the research team based on a previous study. They were controlled to present cyclists and walkers as having higher SE than car drivers.

III. RESULTS AND DISCUSSION

The results of the thematic analysis indicated that the interaction with the app fostered reflection in three main thematic areas as described below:

A. Reflection on own behaviour

The strategies of self-monitoring and feedback on behaviour worked to make participants realise the number and destinations of journeys they make and how active they are, bringing habitual behaviours back into consciousness.

B. Reflection on own Subjective Experience

Having to log and comment on their commutes made participants recall events during the journeys and relate them to their feelings, highlighting the outcomes of travel behaviours.

C. Reflection on others' Subjective Experience

The difference between the control and experimental group was on the presence of other's SE. The visualization of personal and others' SE prompted social comparison, as expected. Also, participants perceived themselves and other car drivers usually displaying a lower SE level than cyclists and pedestrians. The awareness of differences in SE also made participants evaluate and consider other forms of transport.

IV. CONCLUSION

This study constitutes what we believe to be the first intervention to use others' SE as the influencing factor to change opinions and increase motivation to change towards a sustainable transport mode. It demonstrated that the strategies promoted reflection on participants' own travel behaviours and comparison with the (better) experiences of others. Envisioning the possibility of an improved commute experience may be the first step towards the use of active modes of transport. Goal setting and action planning can increase the efficacy of behav-

iour change interventions [2] and this would be an interesting addition to the intervention tested in this study.

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Pymrio - a Python module for automating input output calculations and generating reports

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Abstract—In the last decades, globalization has led to complex supply chains spanning multiple countries. Likewise, environmental pressures caused by production of a certain product are spread across countries. As a consequence, the environmental impacts of consumption are more and more determined by impacts occurring abroad. Environmental extended multi regional input output (EE MRIO) analysis emerged as the prevailing tool to account for all impacts along the global supply chain. EE MRIOs facilitate the tracing of goods and it's embodied (upstream) environmental impacts from the producer to the final consumer. Therewith it is possible to analyse global pollution and resource use through the whole supply chain and consequently calculate environmental (for example carbon-, water-, land-footprints) accounts.

Compiling global MRIO is a complex task, and to date half a dozen such tables / databases have been compiled. Most of these databases are freely available. However, their structures differ from model to model, and handling/analysing MRIOs needs a certain degree of training.

The Python module pymrio aims to ease the handling of global EE MRIOs. With just a couple of commands it is possible to calculate footprints of products, regions or per capita. It allows to aggregate countries to regions (eg. EU, continents) and to modify the sector classifications.

To date, a parser for the recently published EXIOBASE 2 global MRIO has been implemented. The parser for the World Input Output Database (WIOD) and the upcoming EXIOBASE 3 EE MRIO time series is currently in the testing phase. Once a certain MRIO is parsed, various methods can be applied such as restructuring the satellite accounts or aggregation of regions and sectors. Pymrio automatically checks the parsed EE MRIO for missing data necessary for calculating standard EE MRIO accounts (such as footprint, territorial, impacts embodied in trade) and calculates all missing tables.

Various data visualization methods help to explore the dataset. They extract data from various data tables and allows to compare different perspectives (territorial, footprint, impacts embodied in trade) among countries. In addition, reports can be generated (available in various formats like html, latex, rst) for all stressor/impact data available in the MRIO database, either for absolute accounts or per capita. Calculated results can be exported in various format (Excel, csv, sql).

The guiding principle for the development of pymrio was that an EE MRIO database can effectively be represented as an object in an object oriented programming language as for example Python. Parsing a specific EE MRIO database into an instance of such an object guarantees consistent methods for handling and analysing different (MR)IOs.

The development of pymrio follows best practice of scientific computing including unit testing and frequent integration tests. Every implemented algorithm and data han-

dling function is accompanied by a corresponding test harness which ensures the formal correctness of the function. The full source code is available on a public code repository (github: <https://github.com/konstantinstadler/pymrio>) together with an extensive documentation and tutorials.

In the near future, development of pymrio will focus on providing an automatic analysis of EE MRIO time series and to improve the data visualisation capabilities. Among others we plan to implement report generation function which automatically generate flow maps of environmental pressures embodied in trade flows and of chloropeth maps for the estimated footprint accounts.

Quick Wins in existing Data Centers

Evaluation of the OpenDCME Model

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Abstract— *In existing data centers it is not obvious what should be adapted to lower the energy consumption. The OpenDCME model (Open Data Center Measure of Efficiency) helps data center professionals to find these points.*

In our study we first made a review of all existing scientific literature about energy consumption of the components in data centers. This provided a list of possible points to improve and a classification according to the expected impact on energy efficiency.

Then we applied the OpenDCME model to evaluate an existing data center and compared the outcomes with the list of possible improvement measures from the literature.

The conclusion is that the OpenDCME method does not provide all the possible measures found in the literature, and for the potential improvements it provides, it gives no specific practices how to do them. To implement these improvements a specialist from outside or training and education of inside employees is needed.

The details will be presented in the poster.

Keywords—*IT, cooling, building, configuration, energy efficiency*

I. INTRODUCTION

The exploitation of data centers is a multidisciplinary effort. Knowledge is needed about the infrastructure of IT equipment, cooling equipment and the building. The configuration and cooperation of these different types of equipment should be as energy efficient as possible. When a new data center is designed all components can be chosen in an optimal configuration. In existing data centers it is not obvious what should be adapted to lower the energy consumption. The question is: can the OpenDCME model be used to find the points of improvement?

II. RESULTS OF THE EVALUATION

A. The OpenDCME Model

The OpenDCME model [1] is applied to determine the energy efficiency of a data center. In the model it is recognized that the PUE (Power Usage Effectiveness) alone does not provide enough insight which components should be adapted. The model contains sixteen KPI's (Key performance

indicators) divided over four quadrants: Facility, IT assets, Management and Processes. Based on these KPI's a score is determined for the most important systems in the data center and the processes that have influence on the equipment that is used in the data center. These scores provide insight in the points where to improve the energy efficiency.

B. Results of the literature survey

The components to be improved can be divided in electrical and mechanical infrastructure and IT-equipment. We found a list of seventeen improvement measures, divided over the three categories. With respect to electrical infrastructure the data center can be operated at a higher voltage or the amount of AC (alternating current) to DC (direct current) conversions can be lowered [2]. With respect to the mechanical infrastructure several kinds of measures on the cooling can be taken: higher temperature, cooling with open air, compartmentalization, rotation of fans at variable speed [2,3,4,5,6,7,8,9]. For IT-equipment higher operating temperature, consolidation and virtualization of servers and switching off servers that are not used [3,4,7,8,10].

C. Results of the evaluation of a data center of the Ministry of Defence with the OpenDCME model

The OpenDCME model was applied on a data center of the Ministry of Defence in the Netherlands. By doing this in detail we discovered that eight of the seventeen possible improvement measures from the literature were directly or indirectly proposed by the OpenDCME model and nine were not proposed. Above that the model does not give specific practices. Therefore we conclude that a specialist from outside or training and education of inside employees is needed. For this education we recommend an European course [10] in which the Best Practices of the European Code of Conduct on Data Centers [11] form the backbone.

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Repurposing E-waste as a Driver for Resource Efficiency

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Abstract— Resource efficiency has been identified as a key objective to further protect our economic, environmental and societal wellbeing over the coming years. E-waste is of particular interest from a resource efficiency perspective for a number of reasons. It is the fastest growing waste stream and its generation is estimated to grow by 33% in 2017. Many electronic products also contain materials referred to as critical materials by the European Union (EU) because of their economic importance, increasing demand from emerging technologies and also due to potential supply interruption. E-waste also contains significant amounts of precious metals such as Gold (Au), Silver (Ag) and Palladium (Pd). Low collection rates, inappropriate pre-treatment and the absence of recycling technologies means that the resource efficiency for many of these precious and critical materials is very low.

Re-use can extend the use phase and reduce the waste generated from electronic products and is frequently proposed as a means to improve resource efficiency. However, the economic viability of Reuse depends, among other things, on a market demand for the product. Due to rapid innovation cycles many products might be technically reusable but the refurbishment process is not viable from an economic perspective as there are no potential customers for these products.

Repurposing has been defined as “to adapt or use in a different purpose” and has been identified as a representative design strategy for suitable e-waste. It is a promising end-of-life strategy for three reasons: it provides consumers with additional utility from a product they might otherwise discard; it reduces environmental impact if it avoids production of purpose built products and it allows freedom to choose functionality which maximises the potential to avoid primary products. This strategy will focus on extending a products lifetime and preventing early disposal.

The purpose of this paper is to evaluate and test the hypothesis that there may be an economically viable opportunity to add value to e-waste through repurposing certain parts or components from working or damaged devices while in the process, also conducting dismantling of the original product potentially leading to better recycling outcomes.

This poster presents a study for repurposing from a sample of Notebook computers sourced from a formal e-waste supply chain.

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The recycling of computers presents a complex scenario in the area of e-waste as they contain quantities of critical materials and precious metals as well as plastic and steel or aluminium and have been identified as important sources of secondary raw materials. Many of these materials are being lost during the recovery process due to inappropriate pre-treatment such as shredding. These computers also contain parts that are high in embodied energy due to the manufacturing processes employed. The energy used during the manufacture of Printed Wiring Boards (PWB), Processors (CPU) and Memory (RAM) dictates that these components should have an optimal use phase to offset the previous energy use. This paper is proposing that the motherboards from these notebooks could be repurposed as a thin client. The innovation cycles for these types of devices are much longer than for personal and portable computers due to reduced local processing requirements, resulting in lower technical specifications being required.

Keywords—E-waste, ICT, Repurposing, Resource Efficiency.

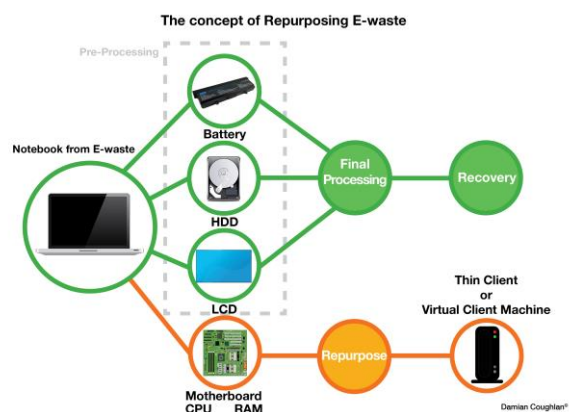


Figure.1 The concept of Repurposing E-waste diagram.

Sustainability Research in Computing: A Taxonomy

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Keywords—*Sustainability; Taxonomy*

I. PROBLEM DEFINITION

A researcher approaching the study of Sustainability will come from one of the many academic disciplines which contribute to its development. The approach will quickly reveal that Sustainability is *multi-disciplinary*: it is the focus of study of several disciplines. This multiplicity naturally leads to the formation of research communities that attract participants from diverse disciplinary backgrounds. The researcher faces the problem of matching his background, interests and objectives within a broader landscape of communities which manifest some measure of isolation, to the general detriment of the field of Sustainability Research in Computing.

Computing itself is *multi-disciplinary*. The Joint Curricula Task Force [1, p.9] aptly defines Computing as “any goal-oriented activity requiring, benefiting from, or creating computers.” Therefore, the landscape of Sustainability Research in Computing has two dimensions (multi-disciplinarity property) that are orthogonal (exist independently of one another).

Consider these examples of the problem:

1. What is the difference between Green IT and Green Computing?
2. What is the difference between Green IS and Green Computing?
3. How does Sustainable HCI relate to any of the above?

II. DEVELOPMENT: A COMPREHENSIVE, EXTENSIBLE FRAMEWORK

Sustainability Research in Computing is purposely chosen as the theme of the framework that attempts to illustrate the landscape for a novice to the field of study of Sustainability. While the present content is richest in the disciplines in which the lead author has been active, effort has been made to recognise the multi-disciplinarity upon which Sustainability depends for its success through the inclusion of significant branches that need further nodes to be added by researchers from other disciplines.

Much of the content of the landscape has been extracted from Hilty's broad overview of the frameworks that have attempted to organise the landscape or portions thereof [2]. Green IT content and perspective was gleaned from Murugesan's and Gangadharan's work [3]; that of Sustainable HCI from DiSalvo et al [4]. This work extends the breadth in

[2] through the provision of a system for classification that substantially facilitates comparison of these frameworks and extraction of attributes of these frameworks. Some such attributes have also been identified.

The framework has the structure of a tree, rooted in the field of “Sustainability Research in Computing”. The first branching is into impact-oriented research and application-oriented research. The first classification of the impact of ICTs was made in Berkhout's and Hertin's report to the OECD [5]. This work identifies the direct environmental impact of ICT and the indirect environmental impact. This branching may be criticised as insubstantial, since all application-oriented research is ultimately directed towards the good of the environment. This criticism is fair but in order to succeed in this goal, impact-oriented research needs the tools and data resulting from application-oriented research. Application-oriented research gathers information about the environment (EIS); it builds models about complex interactions on global scale (e.g. climate change) and local scale (e.g. heat transfer in buildings). Environmental Management Information Systems have been included under impact-oriented research. Research leading to development of EMIS is directed at compliance, reporting and eco-efficiency, each of which are clearly within the notion of impact orientation. Application of Information Systems and Information Technology to Sustainability (“application-oriented research”) possibly holds the greatest variety of approaches to improve Sustainability through Computing. This area embraces the application of Information Systems and Technology to the improvement of the Sustainability of any other field of human endeavour which is in the scope of some discipline and has been recognised by researchers from its background as having an impact on Sustainability.

The framework would be incomplete without structural provision of attributes for the nodes. To date, this has been carried out for the nodes at the level denoted “Community Classification, Level 1”, where “Key Differentiators in Perspective” and “Hints of Isolation of Communities” have been found useful to the declared intention of providing a novice with a map to the field. It is expected that more attributes can be extracted, at this level as well as at level 2 and others that might ensue.

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Sustainable electronics and IT

Building monitoring using wireless sensors

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Abstract. This poster describes and presents how Bachelor Engineering students (3½ year program) are studying sustainable electronics and IT – an elective course given on the 5th or 6th semester. The course is about applied science based on a project chosen by groups of students. The course provides lectures in sensors, embedded systems, sensor networks and protocols, internet protocols, low power design and life cycle screening method.

Keywords: *Sustainable, wireless, sensors, life cycle assessment, low power, embedded systems, building monitoring, problem based projects, education*

I. INTRODUCTION

Sustainability and environmental impact have to be seen in a context and therefore in the course Sustainable Electronics and IT (SUSIE) 10 ECTS points [1], we have integrated sustainability in the context of embedded wireless sensor systems within building monitoring and control. This poster will illustrate how ICT, low power and LCA are integrated in students work. As well as the poster will briefly present the course curriculum. We will show how to teach the more cross disciplinary topics such as life cycle assessment for example.

II. SUSTAINABLE TOPIC

A. Motivation and context

Houses, buildings, products and gadgets contain embedded electronics and software and are connected to the internet. We believe that it is important that students are aware of the environmental impact and are able to design electronic and IT systems with knowledge of their environmental impact. The application domain has been chosen as building control as more than 20% of the energy consumed by the building is for heating and equipment [2]. Low power embedded systems can be used in building control and lead to energy savings.

In parallel with the SUSIE course, a cross disciplinary elective course is given for all 5 or 6 semester students “SDTU Sustainable development and design [3]. Here the students learn about sustainability in product development – products which make DTU - Diplom Campus “greener”. All participants learn about energy screening and lifecycle analysis, regulations and standards for energy consumption in buildings. They create an energy plan and suggest what should be done on the Campus to make it “greener” and for the last 4 weeks they choose a problem based project. We have let the two courses’ students cooperate so students having SUSIE can

support the other course students with prototypes as e.g. light control and monitoring indoor climate such as temperature and humidity.

B. Energy and life cycle assessment of wireless sensors

The purpose is that students learn that the energy consumption is determined by the embedded software programs, protocols used, the wireless radios’ idle and transmission/receiving power and the microcontroller’s and external components power consumption. Last but not least, knowledge of the resources and energy consumption used to produce the electronic devices should be obtained.

During two lessons in this course, a life cycle screening assessment method (MECO)[4] is introduced and the students undertake a screening of a wireless device (XBee module). All the other students on the electronics and IT degree course do not study this.

C. Practical work and lectures

In SUSIE, the students learn how to design a system, focusing on sensors used for indoor climate monitoring, on low power wireless nodes (ZigBee/IEEE 802.15.4 protocols) [5] and their energy consumption along with the energy consumption in embedded microcontroller systems. The students also learn how to use the internet protocol stack for transmitting data to a cloud service.

The practical implementation of this course consists of 9 weeks of overview lectures in parallel with team based hands on lab exercises using Arduino with a LAN shield and XBee [6], [7], and literature studies[4],[8],[9]. Finally, problem based project work is undertaken with the purpose of using all the topics from the classes in solving a self-chosen problem: “Choose a problem domain for which it is relevant to monitor environmental data and controlling actuators, e.g. in a home, at Campus Ballerup, a green house, plant control, electrical vehicle, etc.” The course has been offered for the past 2½ years to Electronics and IT Bachelor of Engineering students. Approximately 20% of all the students have chosen the course. Five out 25 students have continued working with the subject as the topic for their final bachelor project.

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The german POP-Dioxin-Database – Data management of persistent organic substances in Germany

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Abstract—Since 1991 an administrative agreement has been issued in Germany to compile, document and evaluate data from monitoring and surveillance programs at federal and Laender level. Data of more than 200 monitoring programs in respect to PCBs and dioxins in several environmental and human compartments are collected and administrated in a large database system. These datasets are accessible via a web-based Service.

I. EXTENDED ABSTRACT

The POP-Dioxin-Database provides a service for the states and federal authorities that assists them to integrate the collected, quality-assured data into their own applications. Hence, a complex maintenance workflow is needed to administrate and extend the database behind the service application. To overcome SQL-administration, XML [1] was identified as standard exchange format to meet all the requirements of an open interface for environmental data. With the help of configurations of the database, various XML-modules were deployed on the backend and frontend tier. To assure quality of the handled XML documents [2], a built-in validation functionality checks if all child elements are referenced correctly. With the change of the format from SQL to XML we started to generate requirements for a new graphical user interface (GUI) to match actual scientific needs. Therefore, we decided to offer most of the database columns for research and filtering. Users of the former web application had special requirements for information, resulting in requests on the subject of individual result formatting. The new Eclipse RAP-framework application (codename “POPD”) offers various ways to personalize result tables. In an editor page “Output format” the results structure for a query can be described by selecting the individual columns of the results table. Results columns can be added and deleted. They can also be marked as a sort criterion or linked to an aggregation function. The aggregation functions provided are the 1st, 10th, 25th, 50th (median), 75th, 90th, and 99th percentiles, max, min and number (count) [3]. Each column can be added multiple times into the editor page, allowing to add different aggregation functions and display results in a box-plot presentation, for example. Therefore, intersection points for interchangeable, encapsulated modules were realized in the

software development process. Following national open-source initiatives, the developer decided to use the Eclipse framework to process the selection and presentation module (BIRT). In addition, open-source extensions for model-based engineering and application development were integrated in the manufacturing process of the software [4]. To access mathematical features beyond relational algebra, an open interface to the R statistics software environment was realized using RServe [5], a Linux-based server program that responds to requests from clients. Both, the presentation and the statistical module, can be customized and enhanced without source code programming. The aspect of extending chart presentations and statistical functions in a file-based administration module within the web application itself, offers impressive variability of accessing and reviewing result structures. In addition, 2nd-level information about organic substances are offered via direct linking to the Joint Substance Data Pool of the German Federal Government and the German Federal States (GSBL) [6], using official CAS-Numbers as identifier for linked information of the databases. Besides data administration and evaluation on the basis of organic substance measurements, section IV 2.1 (Information Systems on Chemical Safety) offers scientific and ministerial news about POPs by operating the bilingual website dioxindb.de [7]. The portal offers study downloads, event information (including registration links), details on environmental compartments and data modeling. In the near future, the new research application with R-support will be presented to the scientific audience.

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Towards energy-efficient data center infrastructure – a holistic approach based on software for modeling, simulation, and (re)configuration of the energy network

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I. EXTENDED ABSTRACT

According to a data center survey done by DataCenterDynamics Intelligence [1], in the past decade the power consumption of data centers has increased substantially from 18GW in 2007 to an estimated 40GW in 2013 making power consumption an important constraint for new data centers. Also, according to the annual Data Center Industry Survey 2013 by the Uptime Institute [2] the data center average Power Usage Effectiveness (PUE) improved from over 2.7 in 2007 to 1.65 in 2013. This indicates that around 16GW of the total data center power consumption was spent on the infrastructure needed to run and cool the IT systems. Therefore, increasing the energy efficiency of the data center infrastructure and evaluating the possible reuse of waste heat are becoming increasingly important issues in the design and operation of large data centers. In the past this was not a strong focus since all data centers used air cooling. Today, many High Performance Computing (HPC) data centers use a combination of different cooling technologies (chilled water, chiller-less cooling, air cooling, immersion cooling etc.), but there exists a lack of knowledge regarding the energy efficient operation of the different cooling infrastructures which are still designed and optimized for the maximum possible load, like traditional air cooling. However, this peak load is rarely seen in production. For example, SuperMUC (Number 14 on Top500 list from 11/2014) installed at the Leibniz Supercomputing Centre (LRZ) has an idle power consumption of 800kW, an average power consumption of 2.2 -2.4 MW in normal operation, and a maximum power consumption of 3.6MW achieved during the compute intensive Linpack benchmark. The combination of this load variability and the use of new cooling technologies in the data center provides an opportunity to increase the energy efficiency of the data center.

SIMOPEK [3] is one project funded by the German Ministry of Education and Research (BMBF) trying to improve the energy efficiency of modern data centers. It uses a holistic approach based on the “4 Pillar Framework for energy efficient HPC data centers [4]”. The main idea is to create a

model of the data center cooling infrastructure in order to be able to simulate its behavior and to automatically find possible optimizations. For creating a model and to verify and validate the results one needs to be able to collect and use real operational data from both the data center infrastructure (cooling and electrical circuit) and the installed super computer (power consumption and job information). To that end, the Power Data Aggregation Monitor (PowerDAM) software was developed by LRZ. PowerDAM [5] is able to collect data from the LRZ building automation system (Johnson Controls), the power management system (SIEMENS WinCC), from decisive HPC systems (CoolMUC, SuperMUC and SuperMIG) as well as from two batch scheduling systems (Slurm, LoadLeveler). It provides analysis and reporting capabilities, such as, Energy-to-Solution per application, energy budget information on a per user basis, and reports of data center key performance indicators such as PUE and cooling systems Coefficient of Performance (COP). In SIMOPEK, PowerDAM is used to transform and export collected data for model development, and for verification and validation of the simulation and optimization results provided by MYNTS.

MYNTS ([6], [7]), developed by Fraunhofer SCAI, is a software for modelling, simulating, analyzing, and optimizing energy networks (e.g. gas transport, electricity, water). In SIMOPEK, a model of the data center cooling loops, which cool CoolMUC and SuperMUC, was built based on PowerDAM data including a schematic representation of the network (created by SCAI's AutoCAD parser) as well as characteristic fields for involved pumps and other devices. Several scenarios reflecting important operating conditions of CoolMUC and SuperMUC are considered as a basis for simulation, statistical analysis (parameter ensembles) and optimization. The result of the optimization should help to improve the energy efficiency of the LRZ chiller-less cooling infrastructure. Along with decreasing the data center power overhead, created by the cooling infrastructure, the re-use of waste heat could also be beneficial. One possible way to do this is to use adsorption cooling to create cold from the waste heat. Therefore, part of the MYNTS

development is the creation of models describing existing SorTech adsorption chillers and any future developments. This will allow MYNTS to find an optimal adsorption chiller design for data centers.

Overall, the SIMOPEK project is developing methods and software components for modeling, simulating, and optimizing the cooling infrastructure of a data center. The models take into account both the highly dynamic load behavior of the HPC system as well as new technological components (high-temperature liquid cooling) and concepts for recycling the generated waste heat (adsorption cooling by SorTech). In this way, a virtual reconfiguration of the cooling circuits can be performed and studied prior to physically rebuilding the system with the goal to efficiently use and re-use energy.

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Water Quality estimation using statistical and software tools: An ICT intervention

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Abstract— Software's are now becoming excellent tools for understanding the environmental challenges by analyzing the huge data and these huge data are now represented as big data. Open source software's are playing a crucial role in the development of the software application systems. Here the targeted application is an environmental problem for clean water related activity.

Water quality describes the condition of the water, including its chemical, physical, biological characteristics with respect to its suitability for various purposes. Water quality is badly affected by substances like pesticides or fertilizers that can negatively affect marine life when present in certain concentration. A comprehensive environmental data information system helps to perform and complete the common task with less effort for data verification, data calculations, graph generation and proper monitoring which further used in mitigating steps. The main objective of our studies is to create a portal in open source software platform for clean water research activity to better access of the resources among the project investigators. The second aim is to create an online water quality statistical calculation system which gives the calculated Water Quality Index (WQI) based on the water parameter such as pH, BOD, FC, TC etc entered into the software then system would generate message for outliers present in the water parameter data. Data will be compiled, validated from the interface provided to the software. Outliers are being calculated on the water parameter data and then the values being corrected and the initial data get validated also. This software system is developed in such a manner so that it could able to compute the water quality index (WQI) of the river water. The system is developed in open source software platforms/ tools mainly PHP, MySQL and Apache server. System could handle the individual data and the bulk of data as well. For bulk data initial formatting on excel is required for inserting into the system. National Science Foundation (NSF) WQI for various designated best use gave a formula and based on that formula the WQI of the data is being calculated using four water parameter namely pH, BOD, FC, TC, the WQI calculation followed the MPCB Water Quality Standards of class A-II for best designated use. Various category were devised such as very bad category with certainty level of 0–38 % which is unsuitable for drinking purposes; samples in bad category had certainty level that ranged from 38 to 50 %; samples in medium to good category had certainty levels from 50 to 100 %, and the remaining samples were in good to excellent category, suitable for drinking purposes, with certainty levels from 63 to 100 %. Further color coding are given to these categories for example green for excellent, red for bad, orange for medium to good and maroon for very bad, then the graph is generated based on the results, these

results are further shown on gmap which will not only help the users to understand the extent of the water polluted and unfit for drinking by just seeing the map but also help the stakeholder to take decision quickly. Once the calculation is over the system will keep the data for further analysis in future and act as a data bank management system. The developed system will be utilized as a knowledgebase for water quality data. In this way it is seen that Information Communication Technology (ICT) tools are helping in solving the environmental problem timely and in the greater way.

Keywords— *Software's, ICT, Water Quality, Knowledgebase, Open source, PHP, MySQL*

Who? Me? – Responsibility and the E-waste Challenge

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Abstract - The Information Society depends on the highly valuable resource of information that is provided with the help of computers [1]. However, this reliance comes at a high price. Computers require scarce and precious resources (e.g. gold, tantalum), which are mined under inhumane working conditions [2, 3]. Manufacturing occurs in countries in which environmental standards are low, leading to pollution of the environment [2, 4]. When businesses and private users must dispose of their electronic devices, an even more challenging issue evolves - the constantly increasing pile of e-waste. E-waste [5] indicates computer hardware or goods with integrated microchips at their end-of-life [6], whereas WEEE (waste evolving from electrical and electronic equipment) includes every form of hardware used in private households and businesses [5]. The integration of microchips into non-computer products and repurchases of devices due to new technologies [7-9] aggravates the e-waste situation. Lifestyle-indicated repurchases or psychological obsolescence also contribute to this problem [8, 10], which phenomena are related to the perceived need to replace a device (e.g. smartphone) due to non-technical reasons long before the current device's technological end-of-life [11]. At their end-of-life, electronic devices can be refurbished, recycled or disposed [12-14]. Unfortunately, the compound design of some devices makes refurbishment or recycling nearly impossible, inefficient, or even dangerous [5, 14-16]. Designed short life spans to stimulate repurchases or planned obsolescence [17] are associated with this problem. To contain the e-waste flood, green design approaches [15] and reuse scenarios [5] have been developed, but with little success. Unfortunately, the e-waste challenge has global consequences. Used computers, shipped to developing countries and masqueraded as donations to avoid disposal costs [5, 18-20], are cannibalized there. Excavation of valuable materials without safety measures harms the environment and the citizens. Hazardous substances may leak into soil, poisoning it now and into the future [14, 15], and burning of materials pollutes the air [5, 14, 21], potentially leading to increased cancer rates and lower life expectancies [21-23].

However, responsibility for the challenges of e-waste remains unclear. Manufacturers, businesses and private users, governments and civil society could share this responsibility. For businesses, concepts like Corporate Social Responsibility (CSR) assert that companies should accept their responsibility

for economic, environmental and social impacts [24, 25]. These responsibilities have been discussed since the late 1970s [26, 27]. For many years, CSR was defined as a voluntary action of business beyond legal compliance [25, 28], but at present, holistic approaches toward CSR integrate all impacts of companies [29] and consequently apply to e-waste, as well. This research therefore investigates whether organizations adopt responsibility for their e-waste and explores processes related to e-waste. We conducted semi-structured topical interviews with two managers in January 2015, and audiotaped, transcribed and analyzed them. We focused on three general topics: (a) e-waste (what is it, how much is generated, life spans of devices, influence of green design on the buying decision?), (b) end-of-life handling (what is happening to devices at end-of -life?), and (c) perceived responsibility for e-waste (who is/should be responsible for e-waste?).

The analysis showed that the interviewees have a clear idea about what e-waste is, the processes related to it, and the perceived responsibility for it. They identified e-waste as the waste evolving from the end-of-life of computers (servers, personal computers, notebooks, mobile devices) and peripheral components (printers, monitors, input devices, network components). The life span ranges from two (mobile devices) to four (personal computers) and seven (servers) years, with attempts to prolong this period. Typically, companies provide one computer (including input devices and monitor) or notebook and one mobile device per employee; printers are shared among employees. When technical, economic or psychological reasons make devices unusable for business, data stored on the devices is erased or the hard disk is destroyed. These devices may be still usable for private use; hence, reusable devices are (a) sold (on the market or to employees), (b) used as spares, or (c) transferred to partner companies for refurbishment and/or recycling. The latter option also applies to broken devices. Selecting a reliable e-waste management partner with transparent processes is among the highest priorities of the interviewees. Interestingly, green design was not found to influence their buying decisions.

From this analysis, we conclude that selecting the right e-waste management partner is the main explicit (perceived) responsibility [28] for e-waste. The responsibility of the

company ends when its ICT components leave, which is consistent with other findings [30, 31]. Measures such as supporting reuse (selling devices, spare parts) and prolonging devices' lifespans can be interpreted as implicit responsibilities [28]. Interestingly, the issue of protecting data from being disposed with the e-waste was a central concern of the interviewees, making e-waste also a privacy topic. Policy makers are called to support companies in their efforts, by creating clear regulations or incentives to support companies' acceptance of their e-waste responsibility.

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TITLE:

The role of ICT in transforming society through engaged communities

DESCRIPTION:

On the basis that sustainability problems are not amenable to single-point interventions (because they are both wicked and numerous), we need a step-change in how we approach ICT4S. Rather than trying for separate interventions for every aspect, or for passive awareness, focus needs to be placed upon engaging people to affect worldviews. This deeper engagement might be through community conversations, through reflection and so on. This workshop explores the meaning and role of engagement, its potential for change, and how ICT4S can contribute to that.

Workshop structure:

The workshop will be structured around a series of critical-observation role plays. At the start, a set of research questions will be posed. Then, in a series of four mini-workshop activities, workshop participants will swap around roles as activity leader, participant, and critical-observer group. Each role play will explore a different approach to community engagement through ICT4S. Novel practices that will be workshopped include Ferrario's Speedplay, Mann's Participatory Decision Modelling and PAiNT, Larsson's Gasco and Kreitmayer's 4Decades (the selection of these will depend on the outcome of the call for participation). During each role play the critical observer group will (quietly) discuss the approach and at the end will provide feedback to the larger group about their learnings from the process, as will the participants. These learnings will be captured and build towards a final integrative discussion of the research questions and any emergent themes. We envisage these learnings forming the basis of an article for publication.

Who should come to the workshop?

The workshop will be of interest to researchers and practitioners in HCI and related fields such as Software Engineering and Computer-Supported Cooperative Work. You might be experienced in ICT4S or new to the field. We also welcome participants from disciplines such as geography or sociology who could contribute to the political and community engagement aspects, learn what ICT4S has to offer, and build transdisciplinary partnerships.

ATTENDANCE:

Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system. Also, please submit a brief statement describing your interest in this workshop (to samuel.mann@op.ac.nz).

We also invite you to suggest alternative engagement approaches suitable for the workshop. This description should consist of three paragraphs: describing the theoretical positioning of the approach; example(s) of application area; and a brief description of how it would fit into a critical-observation role-play session during the workshop.

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Software Engineering for Social Sustainability

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Abstract—Social sustainability is often deemed to create the basic framework for an operational society. Software too has now become one of the cornerstones of societal infrastructure. Yet, the question on how software engineering impacts social sustainability still remains largely unaddressed. The 1st workshop on Software Engineering for Social Sustainability aims to mobilise an inter-disciplinary community focusing on how software engineering principles and practices must change to ensure maximised positive contribution of an engineered system towards the social sustainability of the societies affected by it.

I. WORKSHOP DESCRIPTION

Social sustainability is often defined as ability of a society to maintain its social capital which creates the basic framework for society, including cohesion of community for mutual benefit, connectedness between groups of people,... standards of ...ethics..., rules, laws, and information... [1]. It lowers the cost of working together and facilitates cooperation, e.g., trust lowers transaction costs [1].

Software systems are prevalent in all walks of life today. It is hard to think of a business, educational programme, or even entertainment industry that does not rely on a software system either for its core activities (e.g., from full pant automation to online games), or payroll, communication, coordination, advertisement, and so on. Surprisingly, even now software systems engineering research and practice severely lacks the consideration of how the software systems (that software engineers develop) contribute to the “basic framework” – i.e., social sustainability – for the society for which these systems are intended. While some research is currently underway on “social software”, the core consideration for such research is how a particular type of software – that used for social networking – is developed and used. The broader question: how software engineering impacts social sustainability remains largely unaddressed.

The **motivation** for this 1st workshop on Software Engineering for Social Sustainability is to mobilise an inter-disciplinary community focusing on how software engineering principles and practices must change to ensure maximised positive contribution of an engineered system towards the social sustainability of the societies affected by it. Such societies can vary from business organisations using software, or localised communities where an organisation/software is located, to distributed online communities that use a given software system.

The Workshop **objectives** are:

- To bring together an inter-disciplinary community, including, for example, software engineers, sociologists, anthropologists, ethics researchers, legal scholars, environment scientists and others, in order to mobilise a community focusing on how software engineering can contribute to better social sustainability.
- Identify on-going research efforts pertaining to software engineering and social sustainability and foster inter-disciplinary collaborations amongst participants.
- Motivate and demonstrate the relevance of this topic to both research and practitioner communities and report on concrete examples of such relevant research and practice.

The workshop will **result** in:

- Initiating discussions/collaborations between those working on various aspects of social sustainability in/through software engineering;
- Creation of the first Report on State of Software Engineering for Social Sustainability to be published at the workshop web site as well as Computing Resources Archive, and
- Initiation of an online repository of example projects to illustrate, motivate, and educate research and development in Software Engineering for Social Sustainability.

All workshop materials will be published on the workshop web page at this URL <http://cazzola.di.unimi.it/se4ss.html>

II. WORKSHOP ATTENDANCE

This workshop is planned as a full-day event.

The workshop solicits submissions of full papers (up to 8 pages), extended abstracts (up to 2 pages), and case studies (2 pages + artefacts). All submissions will be reviewed by at least two program committee members. The main criteria for acceptance will be relevance to the workshop topic and quality of the submission.

Space permitting, any attendee is welcome, but priority will be given to those with submissions. Please sign up through the EnviroInfo & ICT4S registration system.

The workshop activities are briefly itemised below:

- **Panel-centred paper presentations:** Full paper submissions accepted for the workshop will be structured

into panels of 3 to 4 papers. The authors will be invited to give 10 minute presentations on their papers, after which all presenters will form a panel that will engage in active discussion with the audience.

- **Small Group work on Case Studies:** Case Study submissions accepted for the workshop will be structured into domain/problem areas. The workshop participants will split into small groups to work on detailing, clarifying, and aggregating problems and solutions posed by each domain/problem area. The case studies will be collected for the repository of example projects.
- **Plenary discussion on Case Studies and Guidelines:** The session of the workshop will be used for a plenary session. The results will be discussed and integrated into good practice guidelines, and open research questions to set the agenda for the research and practice on this topic.

III. WORKSHOP ORGANISERS

Dr. Ruzanna Chitchyan (contact organiser) is a lecturer in Software Engineering at the University of Leicester, UK. Her research has mainly focused on topics of software engineering and sustainability, as well as advanced modularization techniques (such as product-line and aspect-oriented development). Currently Dr. Chitchyan is researching on topics of software engineering for sustainability (e.g., recent EPSRC All-in-One project) and software user behaviour modification towards sustainable living. She has a particular interest in effects of sustainability requirements on software design, and is one of the main contributors on work around manifesto on Sustainability Design, that aims to distill principles of sustainability design for/through software. Dr. Chitchyan has also worked on issues of technical sustainability within the requirements engineering domain (EU FP7 DiVA, EU FP6 AOSD-Europe and AMPLE projects).

Dr. Chitchyan has a substantial conference and workshop organization experience. She has served, for instance, as the organizing co-chair of ECOOP 2011, and (lead) (co-) organizer on a number of workshops on aspect-oriented development (e.g., at AOSD, ICSE, RE, ECOOP conferences) as well as workshops on Software Challenges and Climate Change (ECOOP 2011 and ICSE 2010). Dr. Chitchyan is currently a co-organiser of the workshop on Requirements Engineering for Sustainability, to be held at Requirements Engineering 2015 conference.

Prof. Awais Rashid is director of the inter-disciplinary Security Lancaster Research Centre at Lancaster University, UK. The centre involves approx. 100 researchers across computer science, engineering and social sciences. His research interests are in inter-disciplinary approaches at the boundary of software engineering, security, sociology, psychology and law. In particular, he is interested in developing sustainable software systems for sustainable living in the digital world – particularly systems that empower otherwise marginalised groups, e.g., young people, the elderly and those on the wrong side of the digital divide. He has led a number of inter-disciplinary research projects funded by the European Commission and UK Engineering and Physical Sciences Research Council in excess of 12M euros. Examples include his work on the UDesignIt

platform that developed novel social media tools to enable communities to come together en-masse to design systems that affect them; work on studying group identities to understand how online groups move from rhetoric to (positive or negative) social actions in the physical world; novel techniques to protect vulnerable online users from frauds, cyber-bullying, etc; and development of frameworks for tackling emergent ethics for software engineering in society. Prof. Rashid has extensive experience of serving on programme committees. He has served on program committees of major conferences such as International Conference on Software Engineering (Software Engineering in Society Track), International Conference on Requirements Engineering, International Conference on Foundations of Software Engineering, International Conference on Aspect-Oriented Software Development (AOSD) and European Conference on Object-Oriented Programming (ECOOP). He was program co-chair of AOSD 2006 and Conference Chair for ECOOP 2011. He has also organised a number of workshops over the years at major conferences including ICSE, AOSD and ECOOP to name a few.

Prof. Walter Cazzola Prof. Walter Cazzola is currently an associate professor at the Department of Computer Science of the Università degli Studi di Milano, Italy and the chair of the ADAPT laboratory. His research interests include reflection, aspect-oriented programming, software evolution, programming methodologies and languages. He is the designer of the mChARM framework, of the Java, [a]C#, Blueprint programming languages and he is currently involved in the designing and development of the Neverlang general purpose compiler generator. He has written more than 100 scientific papers and served in the program committees or editorial boards for the most important conferences and journals on his research topics.

With regards to past workshop organisation experience, Prof. Cazzola has (co)-organised, a number of these, such as workshop series on Reflection, AOP and Meta-Data for Software Evolution from 2004 to 2012; workshop series on Aspect-Oriented Modeling from 2006 to 2009; IFAC Workshop on Distributed Computer Control Systems, 1998; Workshop on Object-Oriented Reflection and Software Engineering held at OOPSLA 1999; Workshop on Reflection and Meta-Level Architectures held at ECOOP2000; Workshop on Experience with Reflective Systems held at WERS 2001, and others.

REFERENCES

- [1] R. Goodland, *Sustainability: Human, Social, Economic and Environmental* in Encyclopedia of Global Environmental Change, John Wiley and Sons, 2002.

TITLE

ICT Enabling Potential for GHG Reductions at a Company- or Sector-Level: Methodological Considerations

DESCRIPTION

For some time already, information and communication technologies (ICT) have been praised as possible key enablers of greenhouse gas (GHG) reductions throughout the economy. Studies referring to this potential have been put forward both by the ICT industry itself and by international bodies such as the European Union. Further, several ICT companies have started to make claims representing the savings presumed to have been induced by their products (ICT hardware and/or services). For these reasons, it is relevant that researchers start digging into this topic to ensure that such claims have a sound basis. To accurately estimate reductions induced by ICT, a comprehensive picture of their positive and negative impacts needs to be drawn. Within the Centre of Excellence for Sustainable Communications (CESC) at Royal Institute of Technology in Stockholm, some partners have therefore started to identify and deal with different methodological issues related to such claims and how to make estimates in a credible way. A number of issues have been identified including, but not limited to, selection of services, allocation, and aggregation. Further discussions are needed within the research community for a stable framework to be agreed upon. We therefore invite participants interested in the enabling effects of ICT and their assessment to discuss how such assessment methods could be developed and used for different purposes.

Part I: In a round of rapid fire, we will first offer each participant the opportunity to motivate his or her interest in the workshop and condense own thoughts on the topic (in up to two minutes with the support of one slide). These slides have to be mailed to the workshop organizers by September 1st. Any previous experience on the methodological aspects of this topic, that participants could share before the workshop is welcome. The focus should be on methodological aspects rather than on results of specific assessments. This, however, is an offer, not a requirement; participants can join the workshop independently of preparing such a slide.

Part II: A few short invited talks (about 4-5 talks) will then highlight different aspects of the topic. Each talk will consist of 10 minutes presentation and 5 minutes of quick questions and answers.

Part III: The third part of the workshop will consist of moderated discussions on 3-4 topics that will be jointly chosen by the participants. Each participant will have to write 3 topics of interest; these will be then clustered and the most popular and/or important topics will be selected for further discussion in groups of around 5-8 people (the number of groups would depend on the number of attendees). The last 30-40 minutes will be reserved for the presentation and discussion of group results.

Note: No papers will be accepted or published by the workshop. If discussions are fruitful, however, a possible outcome is a joint publication (methodological paper) of a subgroup of the workshop participants. This would also foster and continue the discussions across research groups and other involved stakeholders for many months after the workshop itself.

ATTENDANCE :

Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system.

ORGANISERS :

- Pernilla Bergmark, Ericsson Research, Sweden
- Vlad C. Coroama, KTH Royal Institute of Technology, Sweden
- Mohammad Ahmadi Achachlouei, KTH Royal Institute of Technology, Sweden
- Jens Malmodin, Ericsson Research, Sweden

CONTACT :

Pernilla Bergmark, pernilla.bergmark@ericsson.com

WEBSITE :

Not applicable

TITLE:

Interactive session on the Information Platform for Chemical Monitoring (IPChem)

DESCRIPTION:

IPChem - the Information Platform for Chemical Monitoring - is a single access point for locating and retrieving chemical monitoring data collections. The Platform delivers a coordinated approach to accessing monitoring data on chemicals in humans, in food and feed, in products and in the environment. IPChem is a de-centralised system, providing remote access to various sources of Chemical Monitoring data, thus allowing users to search, display and download data from a single interface.

At the IPChem workshop we will provide a practical demonstration and encourage participants to actively test the tool. Our objectives are to promote IPChem to potential users in the EnviroInfo and ICT communities and to receive expert feedback on the utility of the tool, as well as suggestions for improving IPChem architecture and functionality. To achieve these objectives we will:

- actively demonstrate the platform to participants;
- support participants in testing the platform to conduct a case study search across datasets; and
- seek their feedback on the functionality and utility of the platform, as a basis for future improvements.

The long term goal of IPChem is to improve the information base for policy making to minimize the significant adverse effects of chemicals on human health and the environment, an objective agreed at the World Summit on Sustainable Development in 2002 and captured in the EU's 7th Environmental Action Programme.

IPChem is a tool for bridging the gap between national agencies, institutions and researchers that generate chemical monitoring data and policy makers who rely on a robust evidence base for decision making. The inclusion of additional data sets under IPChem serves to enhance its coverage by pulling in data at a broader spatial and temporal range, as well as its scope in the chemical substances covered. We invite data providers to approach us and discuss modalities for the inclusion of their data in IPChem, either at the workshop or during breaks.

Workshop duration: 1.5 hours.

ATTENDANCE:

Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system.

ORGANISERS:

Peter Korytar, European Commission, DG Environment Catherine Ganzleben, EEA Silvia dalla Costa, European Commission, Joint Research Centre, Institute for Environment and Sustainability

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<http://ipchem.jrc.ec.europa.eu/>

TITLE:

ICT-enabled Amateur Weather Networks - motivations and barriers for citizen participation

DESCRIPTION:

This is a short workshop, with a total duration of 1.5 hrs.

In the face of diverse climate change implications such as floods and droughts, continuous and widespread observations of the environment are of crucial importance to equip authorities and citizens in at-risk locations with essential information as they have to deal with more frequent and/or more intense flood risk hazards. Yet there are two major problems with the traditional means of observing the environment using Remote Sensing (RS) and in-situ observations; firstly, the low resolution and density of the data acquired using these methods and, secondly, the passive role that they perceive for citizens in terms of understanding their environment. The importance and potential of involving citizens in gathering data about the environment and also higher levels of participation in environmental governance and decision making are on the increase. In parallel, the diffusion of Information Communication Technologies (ICTs) that are interactive and easy to use have provided new horizons for facing climate change and the threatening hazards resulting from that. These two trends have given birth to 'Citizen Observatories' that are contemporary, innovative and community-based form of environmental monitoring. Nevertheless, the success of citizen observatories hinges on the continued involvement of citizens as central actors of these initiatives. Developing strategies to (further) engage citizens requires an in-depth understanding of the behavioral determinants that encourage or impede individuals to collect and share environment-related data.

An example of ICT-mediated citizen observatories is online amateur weather networks. These initiatives that were initially formed spontaneously and based on the impulse of individuals are attracting more and more members. Recent empirical research carried out in the Netherlands, United Kingdom and Italy has elicited the main drivers and barriers for citizen participation in sharing their personally collected weather data via online weather networks. The main objectives of the workshop are to share these findings and contrast them with the participants own experience in an interactive setting and to turn these insights into action for improved citizen engagement strategies.

The workshop will start with an introduction of some of the major existing Amateur Weather Networks to familiarize the participants with the evolution of these platforms, their current status and their future potential. Next, the main drivers and barriers for citizen participation in sharing personally collected weather data via online weather networks identified by the research are discussed in the light of the participants' own experiences and expectations. Finally, we will discuss how we can strengthen engagement strategies to (further) involve citizens to collect and share environment-related data.

ATTENDANCE:

Any attendee is welcome. The workshop is of particular interest for those with a keen interest in citizen science, citizen observatories and the role of ICTs in environmental management and governance. Please sign up via the EnviroInfo & ICT4S registration system.

ORGANISERS:

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29 June 2015

Kati Mattern, André Jol, Christian Xavier Prosperini, Ana Gomes and Emiliano Ramieri

Enviroinfo Abstract for workshop on 08n September**Workshop TITLE:**

Interactive session “Sharing knowledge on climate change adaptation at European level – the European Climate-Adaptation Platform (Climate-ADAPT)”

DESCRIPTION:

Climate-ADAPT - the European Climate-Adaptation Platform - is acknowledged in the EU Strategy on Adaptation to climate change (2013) as a key element in ensuring decision-making on adaptation, to provide the best available information at EU level. It helps users to access and share information on the expected climate change in Europe, on the current and future vulnerability of regions and sectors, on national and transnational adaptation strategies, adaptation case studies, and potential adaptation options as well as on tools that support adaptation planning.

At the Climate-ADAPT workshop we will provide a practical demonstration of the different features of Climate-ADAPT and encourage participants to actively test the platform. Our objectives are to ask for feedback by experts of the EnviroInfo and ICT communities on the utility of the features, as well as suggestions for improving Climate-ADAPT functionalities. Furthermore, will also engage potential users in this community to know the tool. To achieve these objectives we will:

- actively present the platform and the information on the use of the platform
- supporting participants in exploring the functionalities of the platform
- seek their feedback on the functionalities and utility of the platform as well as to the evaluation framework.

The long term goal of Climate-ADAPT is to facilitate the collection, sharing and use of information on climate change impacts, vulnerability and adaptation to build a consistent and updated knowledge base. It is intended to assist an effective uptake of the relevant knowledge by decision makers and to contribute to a greater level of coordination among sectors and institutional levels. The intended users of Climate-ADAPT are governmental decision makers and organizations providing them support, working on adaptation at transnational, national and sub-national level (e. g., cities). Its geographical scope is the EU 28 member states, and the non-EU 5 EEA member countries. The information is available in English. The platform is complementary to the platforms at national and transnational levels. We invite organisations providing information on adaptation in sectors to approach us and discuss modalities for the inclusion of links to their websites either at the workshop or during breaks.

Workshop duration: 1.5 hours.

ATTENDANCE:

Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system.'

ORGANISERS:

Kati Mattern, André Jol, Christian Xavier Prosperini (EEA), Emiliano Ramieri and Ana Gomes (European Topic Center on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA))

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TITLE:

Still heating the environment or already saving costs? - Workshop on data center cooling infrastructure challenges and solutions

DESCRIPTION:

For the past decade the energy consumption of data centers has increased quite substantially. For the year 2014 the world wide power consumption was estimated at 38.84 GW. The aggregated power consumption of all HPC systems in the November 2014 Green500 list was 592.31 MW (which does not include the data center cooling overhead). According to DataCenterDynamics Intelligence the average data center Power Usage Effectiveness (PUE) world wide was in the range of 1.81 and 2.0 for 2013. An Uptime Institute survey showed an average PUE of 1.65 for 2013. Using the average of both surveys (1.78, which is most likely very optimistic) 17GW of total data center power consumption was spend on the infrastructure needed to run and cool the IT systems. Therefore, the reduction of energy consumption and the possible reuse of waste heat becomes increasingly important issues in the design and operation of large data centers. If we talk about data center energy efficiency we need to talk about cooling technologies. In the past this was not a strong focus since all data centers used air cooling. Today, many super-computing data centers use a combination of different cooling technologies but there exists a lack of knowledge regarding the energy efficiency of the different cooling infrastructures and their efficient operation. Current data center infrastructures are, like traditionally air cooling, designed and optimized for the maximum possible load. But this peak load is rarely seen in production.

Additionally, previous systems showed not a big difference between idle and load power consumption. But advances in energy efficient processor architectures have increased the variability in the energy consumption of HPC systems quite substantially (for example, SuperMUC [Number 14 on Top500 list from 11/2014] has an idle power consumption of 800kw, an average power consumption of 2.2 -2.4 MW in normal operation, and a maximum power consumption of 3.6MW achieved during Linpack benchmark). This increased variability coupled with the conservative infrastructure design creates great challenges for running the data center infrastructure efficiently.

But the combination of this new load variability and the use of new cooling technologies in the data center (chiller-less cooling) provides an opportunity to increase the energy efficiency of the data center.

This workshop will highlight challenges and solutions associated with the increase of energy efficiency in HPC data centers and the reuse of waste heat, and will highlight some opportunities where data centers naturally connect with a smart city idea.

Format:

The state of the art cooling infrastructure at the Leibniz Supercomputing Centre is used as a concrete example to highlight challenges and possible solutions, which might prove important for more and more data centers in the future. Keynotes will be presented by technology leaders looking into the possible future of IT cooling requirements and the integration of data centers with the surrounding environments via re-use: Gustav Bergquist, CTO, Bahnhof AB; Patrick Ruch, IBM Research Rueschlikon, and Andrey Semin, HPC Technology Manager Intel.

ATTENDANCE:

'Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system.'

ORGANISERS:

Torsten Wilde

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Tanja Clees

Fraunhofer Institut für Algorithmen und Wissenschaftliches Rechnen (SCAI) Schloss Birlinghoven, 53754 Sankt Augustin

CONTACT:

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TITLE:

KPI4DC: New Key Performance Indicators for evaluating DC energy sustainability

DESCRIPTION

Today, more than 50 % of the world-wide urban population are living in urban areas and more than two thirds of our energy is consumed in cities. The impact of cities on climate change is therefore high. This is one reason why cities need to become smart and optimize the energy consumption of their inhabitants among others according to the availability of renewable energy.

Inside cities, data centres are one of the major consumer groups of energy – specifically of electrical power. Technically integrating data centres into the energy management of smart cities and enabling data centres to take part in renewable energy demand side management schemes are the goals of 8 EC co-funded projects, which share the global aim of increasing renewable energies use, heat reuse and the utilization of Smart Grids.

An 8-projects Cluster (containing 50 partners involved) has been created in order to standardize their procedures as much as possible, to ease the further evaluation of the results obtained. The goal of the Cluster is to ensure that if the projects measure a common variable, they are going to use the same metric measured in the same way. By doing this, the information coming from the results of each project will be directly comparably and understandable by the other members of the Cluster, making feedback gathering way more efficient. All projects are collaborating with DC standardization organizations to define a common metrics framework for DCs. New metrics are promoted to be standardized, the focus being on the energy behaviour of the DC and its alignment to the 20-20-20 European goals.



Figure 1 - The projects membership of the cluster

Metrics that will be presented in the workshop can be classified in the following categories:

- Flexibility mechanisms in Data Centres: adapting the power/energy consumption in Data Centres, by shifting workloads from peak to valley hours/to times when more renewable or waste energy is available/to lower price hours
 - Demand shifting: workloads are shifted from a time period to another, but always within the same Data Centre.
 - Demand being federated: capitalizing on other Data centres.
- Renewable energy consumption: maximizing the renewable energy usage
- Energy recovered: capability of waste energy being reused in the same Data Centre or in another close consumer
- Primary Energy consumption and CO2 emissions: total primary energy consumption and emissions of the Data Center.
- Economic savings in the energy expenses: Economic savings that can be obtained in a DC as a result of performing flexibility mechanisms, energy efficiency measures, etc.
- Capacity planning and capacity management, with the objective to relate the designed and the installed capacity with the actual load. It is important to note that this group of metrics is not going to provide information about the energy efficiency of the DC. However, capacity management is a key issue in modern Data Centres operators.
- Grid interaction indicators, with the objective of representing the degree of independency of a DC from the electrical system due to the installation of onsite electricity generation.

The main objective of this workshop is to present to the different stakeholders the benefits that an appropriate usage of Key Performance Indicators can provide as a tool to assess (and improve) DC energy, economic and environmental behaviour to the IT industry. This also fosters the adoption of energy sustainable solutions in the Data Centre field by the Smart City authorities (policy makers).

ATTENDANCE:

Besides the name, email address and affiliation (normal registration) no advance submission is requested. Therefore Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system.

ORGANISERS:

- María Pérez Ortega: Freemind Consulting, BE
- Silvia Sanjoaquin Vives: Gas Natural Fenosa, ES

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WEBSITE:

Under construction: <http://www.dc4cities.eu/KPI4DC.html>

TITLE:

A social practice perspective of the smart grid – Lessons learnt and yet to be discovered

DESCRIPTION

The smart grid has now been “in vogue” for about 10-15 years – both in the research communities as well as within policy-making and the electricity sector. Concurrently, we have witnessed the upcoming of the practice theory approach, which has today become widespread within Academia and some design approaches. Several practice theory-inspired studies of the use of smart grid technologies in everyday life settings have been conducted.

The early years of the smart grid development were characterized by a enthusiastic and optimistic approach to the possibilities of the smart grid, including the role of customers and households in taking active part in the transformation of the energy system. However, recent years we seem to have been witnessing a less enthusiastic (or, some might say: more realistic) approach to the prospects of the smart grid and the role of households. The time might have come to take stock of the research and design experiences within the smart grid field, including learnings based on a practice theoretical approach.

Questions for this workshop could be (but are not restricted to):

- What are the key learnings from practice theory studies of everyday life and smart grids?
- Are we entering a less enthusiastic – but more realistic – phase in the smart grid development?
- What kind of smart grid technologies and initiatives are actually working in “real life” by now? What are the successes and failures?
- How has practice theory supported a better understanding of the smart grid? And better solutions?
- Do the practice theory research community and the design & development and business sector learn from each others?

The workshop is a half-day workshop divided into two sessions. The first session will be a round of short presentations of current research projects/findings (about 5-10 minutes per presenter). The second session will be a more general discussion on basis of topics that interest the participants and cuts across our different research projects.

ATTENDANCE:

Any attendee is welcome. Please sign up through the EnviroInfo & ICT4S registration system. The participants will be encouraged to prepare a short presentation of their current research activities/projects. Written papers are not required.

ORGANISERS:

Cecilia Katzeff (Interactive Institute Swedish ICT)
Annelise de Jong (Interactive Institute Swedish ICT)
Toke Haunstrup Christensen (Aalborg University)

CONTACT:

Toke Haunstrup Christensen (thc@sbi.aau.dk)

WEBSITE:

None

TITLE

Data Centers, Energy and Sustainability

DESCRIPTION

The key aims of this workshop are to share knowledge about trends in data center energy usage and best-practice experiences, to explore innovations that further reduce energy consumption in data centers, and to identify game-changing approaches that meet wider sustainability ambitions.

The workshop will follow a highly participatory approach. We are happy to announce that the ICT4S conference facilitator, Peter Woodward, will be the moderator and facilitator of the workshop as well. The workshop will thus alternate between rapid impact presentations on key findings and state-of-the-art, discussions in small groups of maximum seven attendees, and feedback given to the plenum.

The workshop will be divided in three parts:

The first, relatively short part will introduce the workshop's participatory format, and set the stage by addressing the elephant in the room: what is the size of the issue being under discussion? (worldwide data center usage and energy requirements, expected developments).

The second part will address traditional indicators for data center energy efficiency such as the "Power Usage Effectiveness" (PUE). After steadily improving for the last decades, data centers recently hit what was named the "PUE plateau" – a value that proves difficult to improve. The impact presentations of this part will present examples of current innovation to breach the PUE plateau, as well as further innovative ways for increasing the sustainability of data centers – e.g., the reuse of waste heat generated by the data center for district heating.

Table groups will then identify top 5 savings opportunity areas and give feedback to the plenary. In a prioritization exercise, a composite list will be created and the top opportunities distilled. The second part will finish with the table groups exploring these top areas and highlighting research and action possibilities.

For the third and final part all bets will be off! Using a similar structure as part 2 (impact presentations, table discussions, feedback to plenary, prioritization), this part will seek big ideas for paradigm shifts on the energy consumption of data centers, as well as on their broader sustainability.

Notes:

- The impact presentations include talks by Google, Ericsson, TeliaSonera, and others tbc.
- The workshop will be hosted by Google Copenhagen, only a few minutes outside the conference venue. A buffet lunch will be offered on-site between 13.15-13.45, before the start of the workshop.
- The workshop does not require or publish contributions by the attendees.
- Workshop registration is only 10€, but participants need to be registered at least one day for the conference. Please see the conference guidelines: <http://enviroinfo2015.org/fees-and-registration/>.

ATTENDANCE:

Any attendee from industry or academia is welcome. The workshop can accommodate up to 50 attendees, who will be selected on a first-come, first-served basis.

ORGANISERS:

- Vlad C. Coroama, KTH Royal Institute of Technology, Sweden
- Iarla Flynn, Google UK
- Matt Kallman, Google US
- Mattias Höjer, KTH Royal Institute of Technology, Sweden

CONTACT:

Vlad Coroama, coroama@kth.se

WEBSITE:

Not applicable

TITLE: Infrastructures and Platforms for Environmental Crowd Sensing and Big Data**DESCRIPTION:**

Recent technological advances, such as mobile internet, smart phones and the Internet of Things (IoT), resulted in an unprecedented wealth and diversity of data. Big Data, i.e. tailored knowledge extraction from these new sources, became popular in almost all sectors of industry and research. Especially user-generated Web content from crowd sensing provides new and sometimes unique sources of environmental information. The integration and application of these sources – often termed crowdsourced Geographic Information or Volunteered Geographic Information (VGI) – creates a novel inter-disciplinary research area involving diversified topics across multiple spatial and temporal scales.

EU-funded COST actions, such as ENERGIC (IC1203) or Mapping and the Citizen Sensor (TD1202) already contribute to this research field. The FP7-funded Citizens' Observatories projects (<http://www.citizen-obs.eu/>), Citclops, CITI-SENSE, COBWEB, Omniscientis and WeSenseIt, collectively develop novel technologies and applications in the domain of Earth Observation and citizens' involvement, aiming at crowd sensing of observations in various domains such as air quality, water quality, flooding, land use and biodiversity. A new set of Citizens' Observatories is now proposed as part of the Horizon 2020 call SC-5 in order to ensure further development, testing and demonstration in real conditions. All together, these activities help to quickly advance the theoretical underpinnings of Environmental Crowd Sensing and Big Data, but also propose new methods and tools for data capture, information extraction and knowledge creation.

This workshop particularly addresses the technologies, technical infrastructures, platforms and services that are originated or used by these projects. We are especially interested in exploring the synergies between ongoing efforts, the exchange of lessons learned and potentially required standardisation work to ensure interoperability of the developed solutions. Accordingly, this half-day event intends to bring together architects and developers working on crowd sensing infrastructures, architectures and platforms and related Environmental Big Data including sensing data through the IoT. We will especially debate the questions: (1) Which functional components are essential to support our work? (2) Can we create a common data model for citizens' observations? (3) Can we create a common framework for smart phone apps for crowd sensing? (4) How might we sustain infrastructures and platforms that enable Environmental Big Data and Crowd Sensing? (5) Where do we see most urgent needs for additional research and development?

The workshop topics will extend from the recent Crowdsourcing workshop during the INSPIRE'2015 conference in Lisbon (on Friday, 29 May 2015),
http://geospatialworldforum.org/workshop.asp?Sp_Department=Crowdsourcing

After this workshop at EnviroInfo'2015, participants will be invited to continue and intensify the discussion with the wider community, including extended debates during a follow-up event later in the fall, and contributions to a special issue of the Journal for Spatial Data Infrastructure Research (IJDSIR) on Crowd Sensing. This collection of full scientific papers shall then reflect the latest state of play with respect to Environmental Crowd Sensing and Big Data and point to the required research for the years to come.

ATTENDANCE:

The target audience includes representatives of relevant projects and activities, as well as public authorities involved in data production or in the development of environmental information systems, people involved in ongoing initiatives (e.g. citizenship, community mapping, environmental monitoring), young researchers

and doctoral students, academia, other organizations which can benefit from crowd sensing results (e.g. participatory mapping for development-oriented interventions), citizens (user generated content is an enabling technology to exchange information with others), teachers, Web operators, IT companies and public institutions that, for different purposes, make use of geographic information.

The typical workshop attendee is assumed to be involved in the development or use of the infrastructures, architectures, apps, or platforms for Crowd Sensing, Citizens' Observatories and Environmental Big Data.

In order to prepare for a productive dialogue, please submit a (1 page) position statement by e.mail to the workshop organisers before July 31st, 2015.

ORGANISERS:

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